MARYLAND BIOLOGICAL STREAM SURVEY 2000-2004

Volume X

Riparian Zone Conditions

MARYLAND
DEPARTMENT OF NATURAL RESOURCES

CHESAPEAKE BAY AND WATERSHED PROGRAMS
MONITORING AND NON-TIDAL ASSESSMENT
CBWP-MANTA-EA-05-7

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Riparian Zone Conditions

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FOREWORD

This report, *Maryland Biological Stream Survey 2000-2004 Volume 10: Riparian Conditions*, was prepared by Matt Kline and Robert Hilderbrand of the University of Maryland, Appalachian Laboratory, and Anne Hairston-Strang, of the Department of Natural Resources, Forest Service. It was supported by Maryland's Power Plant Research Program.

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ABSTRACT

During the 2000-2004 MBSS, 58% of stream miles had 50 m wide or greater vegetated riparian buffer areas, statewide. Forests were the most common (68% of sites) land use adjacent to buffers, followed by cropland, pavement, and mowed lawn. The most common buffer breaks were pasture and cropland. Other frequently found severe breaks included impervious surfaces and storm drains, which would preclude any natural treatment as water passed through buffer areas. Although infrequent, instances of suspected raw sewage reaching streams were also recorded. The types and extent of buffer breaks found varied greatly by county. Counties where agricultural land use (e.g., Carroll, Washington, Worchester, Wicomico) was common tended to have pastureland and crop areas included in buffer areas, along with dirt roads. Buffer breaks in more urban counties (e.g., Baltimore County, Baltimore City, Harford, Prince Georges) tended to have breaks from storm drains and other impervious drainages, including concrete-lined ditches.

In addition to reporting on the extent and condition of riparian buffers, this volume also summarizes MBSS results for, shading, channel alteration, invasive plants, rootwads and large woody debris, and beaver activity. Results for each of these are summarized below:

Most of the randomly selected MBSS sample sites were over 80% shaded. As expected, smaller streams (first or second order) tended to have a higher percent of shading. Shading on third order and larger streams tended to be more related to the presence of forest cover in the riparian zone, but the variability in tree cover adjacent to water is great even where buffers were quite wide (50 m).

The most common type of channel alteration was earthen ditching, found at an estimated 11% of all stream miles. Concrete channels (5%) and rip-rap (5%) were the next most common types.

While invasive plant species were present at most of the sample sites, extensive growth was recorded at less than 20% of all sites. Invasive plant species were present at nearly every sample site in central Maryland where urbanization and agriculture are widespread. The most common invasive plant was multiflora rose (present at 69% of sites), followed by Japanese honeysuckle (61%), Japanese stilt grass (39%), mile-a-minute (26%), thistle (13%), and phragmites (3%).

Statewide, the mean number of instream woody debris was 4.0 per stream reach. The greatest mean amount was found in the Nanticoke basin (13.3). Statewide, as well as in the Coastal Plain and Piedmont physiographic regions, fish index of biotic integrity scores increased with increasing woody debris. Fish index of biotic integrity scores were not significantly related to woody debris amounts in the higher gradient streams of the Highland region, where alternative large cobble and boulder habitats are common.

Beaver activity varied dramatically by region and county. However, beaver activity was estimated to be present at 6% of Maryland’s stream miles.

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10.1 INTRODUCTION

Riparian zones – derived from the Latin word *riparius* meaning "of or belonging to the bank of a river" – are important interfaces between terrestrial and aquatic ecosystems, especially those biotic communities associated with open freshwater systems such as rivers, streams, lakes and ponds (Naiman and Decamps 1997). Riparian zones serve a number of critical ecological functions. They control erosion and sedimentation, modulate stream temperature, provide organic matter, and maintain benthic macroinvertebrate communities and fish assemblages (Lee et al. 2004). Riparian zones provide critical habitat for many animals adapted to these habitats. Riparian zones provide travel zones for many species and provide winter cover. Biotic communities in the riparian zone, especially vegetation, are highly dependent on the hyporheic zone - the active ecotone between the surface of streams or lakes and groundwater (Boulton et al. 1998). Overall, riparian zones are important components of the landscape even though they usually represent a small percentage of actual watershed area.

Destruction of riparian zones reduces wildlife habitat and corridors, important not only to resident fauna but also to migrating organisms (Sweeney et al. 2004). Direct effects on streams include loss of organic inputs (woody debris, leaf litter and dissolved organic carbon), reduction of shading (affecting stream temperature and periphyton), and reduced buffering from pollutants (Naiman and Decamps 1997, Sweeney et al. 2004). Riparian buffers are important in maintaining stream health and providing ecosystem services (Sweeney and Czapka 2004). In addition, riparian zones appear to be highly vulnerable to invasive species that reduce biocomplexity and alter riparian function by competing with native species (Naiman and Decamps 1997).

Forest buffer functions can be diminished by many threats, including insects, disease, deer, and invasive plant and animal species. Introductions of exotic insects and diseases, particularly from Asia, are increasing along with global trade, posing risks to native forests. The hemlock woolly adelgid is responsible for weakening and killing hemlock trees over much of the Eastern US. Hemlocks are one of the most common conifers in riparian areas, so their loss has implications for stream shade, aquatic food sources, and future large woody debris for habitat. Other emerging forest threats include the emerald ash borer, which is responsible for losses of large areas of ash trees in Michigan; sudden oak death, which is killing oaks and damaging many other tree species on the West coast; and the Asian long-horn beetle, which threatens maples and other tree species in the Northeast. All of these threats have the potential to dramatically alter species composition in forests, and are being transported to new locations despite quarantines, restrictions on shipping nursery stock, and random inspections of solid wood packing material. In addition to ecological and aesthetic impacts, tree defoliation or death also accelerates nutrient release, which is undesirable for watershed health (Lovett et al., 2002). A variety of efforts including chemical control, sanitation cutting, quarantines, and public education are aimed at controlling impacts and spread. Biological controls for exotic pests already present in the state have been implemented successfully to limit some threat populations. The reduction of gypsy moth following the introduction of an internal fungus is an example of one of these successes.

Deer browse is a natural part of ecosystem processes, but high density deer populations are browsing at unprecedented rates in some areas of Maryland; consequences include overall reduction in regenerating trees and changes in species composition with preferential browsing (Seagle and Liang, 1997). Exotic invasive plants are interfering both with native forest composition and the establishment of new forests in places where they have been long absent (e.g., unbuffered stream riparian zones). New forests require active maintenance for two to five years following establishment to assure tree growth and to avoid extensive damage from deer and invasive plants.

Maryland has committed to increase riparian forest buffers in the state through the Chesapeake Bay Agreement and the 2003 Riparian Forest Buffer Directive. The long-term goal is to have at least 70% of Chesapeake Bay waterways with forested buffers. A short-term goal is to establish 10,000 new miles of buffers between 1996 and 2010. Marylanders created 1173 miles of new buffer between 1996 and 2005, and need an additional 858 miles before 2010 to meet statewide goals. A variety of incentive programs are available to support establishment of new forest buffers, including the Conservation Reserve Enhancement Program, Forest Land Enhancement Program, and Environmental Quality Incentive Program.

This volume summarizes the condition of stream banks and the riparian areas immediately adjacent to streams. Sections are provided for riparian vegetated buffers, riparian buffer breaks, shading, invasive plants, rootwads and large woody debris in and near stream channels, and beaver activity.

To limit the size and complexity of this volume and increase readability, all methods used to prepare and analyze data for this volume are presented in 2000-2004 Maryland Biological Stream Survey Volume 6: Laboratory, Field, and Analytical Methods. This volume can be downloaded from http://www.dnr.Maryland.gov/streams/pubs/ea05-3_methods.pdf.

10.2 RIPARIAN VEGETATED BUFFERS

The ability of riparian zones to ameliorate nutrient loading and provide other benefits to streams (e.g., shade, overhead cover, leaf litter to feed macroinvertebrates, and woody debris) varies with the type and amount of vegetation. Statewide, 58% of stream miles had 50 m wide or greater vegetated riparian buffer areas during the 2000-2004 MBSS (Figure 10-1). This vegetation was predominantly forest. However, 10% of stream miles had no buffer at all, and another 5% had buffers between 1 and 5 m wide. Over 60% of stream miles statewide had forested buffers on both sides of the stream, although percentages varied substantially by county (Figures 10-2 and 10-3). Harford County had the lowest percent (47%) of forested buffer on both stream sides.

While many of the buffers along Maryland streams were forested, they were most commonly dominated by < 4 inch diameter deciduous trees or 4-12 inch diameter trees. Large trees (12-24 inch diameter) and old trees (> 24 inch diameter), conifers, and mowed lawn were more common in the Highlands region than in the other regions of the state. The Highlands region also had the highest percentage of stream miles (13%) with no riparian buffer (Figure 10-4).

The land use immediately adjacent to the riparian buffer may affect the volume of pollutants in runoff. Forested watersheds tend to have the lowest nutrient output and runoff, while agricultural lands tend to have much higher nutrient loads and higher runoff. Developed lands have variable nutrient loads and may have high runoff due to impervious surfaces. Statewide, forests were the most common (68% of sites) land use adjacent to buffers, which is a positive sign for long-term stream health (Figure 10-5). The percentage of sites that had forested adjacent areas was substantially higher than the average statewide forest cover of 41%, suggesting that streamside areas tend to have more forested land cover than other areas. Cropland, pavement, and mowed lawn were the only other adjacent land use types that were present at 10% or more of the sample sites. The high proportion of paved roads as the adjacent land use reflects the propensity of engineers to construct roads along stream corridors, where gradient changes are most gradual.

In the Eastern Piedmont region, forest was the adjacent land use type at 58% of sites sampled (Figure 10-6). Agricultural and urban land use categories (paved roads, housing, pasture, cropland, mowed lawn, and old field) were all present as the adjacent land use at ≥10% of the sample sites in this region, documenting the Eastern Piedmont's higher population density and degree of urban development. More than 75% of all sample sites in the Coastal region had forest as the adjacent landuse type. In contrast to the Piedmont region, cropland was the second most common adjacent land use (21%) in the Coastal region (Figure 10-6).

Elevated nutrient levels can result in excessive algal growth and undesirable changes in aquatic conditions. Nitrogen (N) tends to dissolve readily in water and travel with groundwater and surface runoff to streams. Phosphorus (P) does not dissolve as readily and tends to travel primarily as surface runoff. MBSS water samples are collected at non-storm conditions during the spring index period (March-April). Thus, MBSS stream nutrient concentrations are representative of conditions present during that time period only.

Although instream nutrient concentrations typically reflect upstream inputs and watershed land use patterns rather than conditions near the sampling site, an analysis of linkages between forested buffers, stream order, and land use was conducted. No relationship was found between nitrate (NO_3) and forested riparian buffer width. However, first order streams tended to have the lowest nitrate concentrations, with N levels increasing with stream order (Figure 10-7). Third and fourth order streams drain larger catchments that are typically affected by more buffer breaks and a greater variety of land uses. These watersheds are less likely to be predominantly forested, and have higher average NO_3 levels.

The effect of agricultural land uses is seen in Figure 10-8, where agriculturally dominated basins averaged nearly four times the NO_3 level of those with less than 25% agriculture, however, no relationship was found between NO_3 levels, the percentage of upstream agricultural land use, and riparian buffer width. Almost all NO_3 concentrations were well below the drinking water standard of 10 mg/l, although the increased nutrients could become a problem for downstream habitats like the Chesapeake Bay or Atlantic Coastal Bays.

Instream total phosphorus measurements were typically an order of magnitude lower than nitrate levels, which is common in streams. The patterns by stream order and agricultural land use seen with nitrates were not readily apparent for phosphorus (Figures 10-9 and 10-10). No relationship was found between P levels, the percentage of upstream agricultural land use, and riparian buffer width. Much of the P transport can occur during storms, moving with sediment in overland runoff, and would not be reflected in the instream levels between storms, when streams were typically sampled.

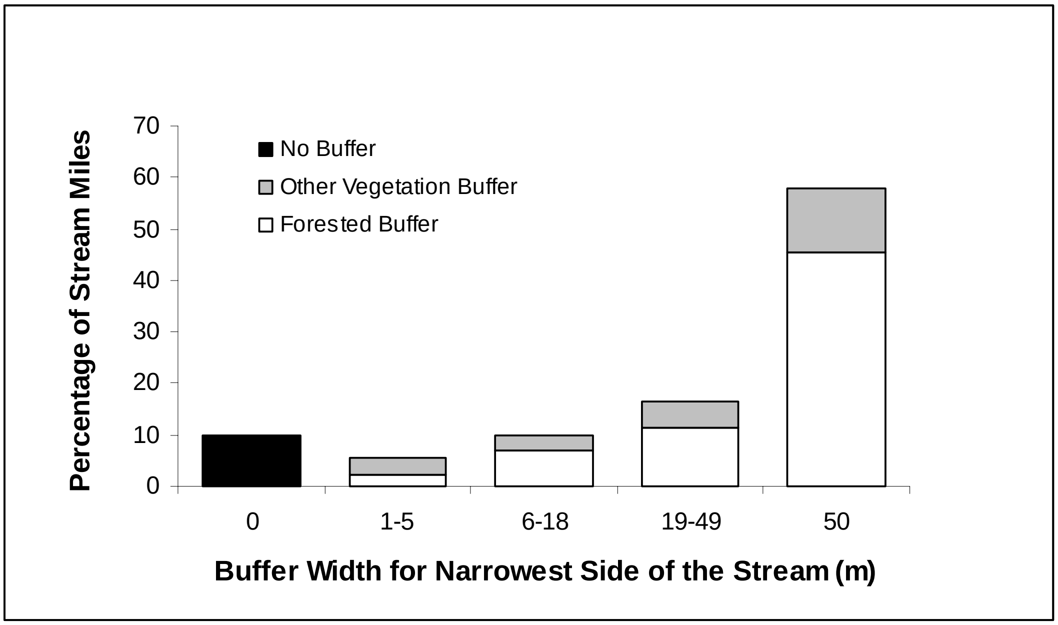

Figure 10-1. Buffer width in meters by percentage of stream miles in Maryland, based on data from the 2000-2004 MBSS

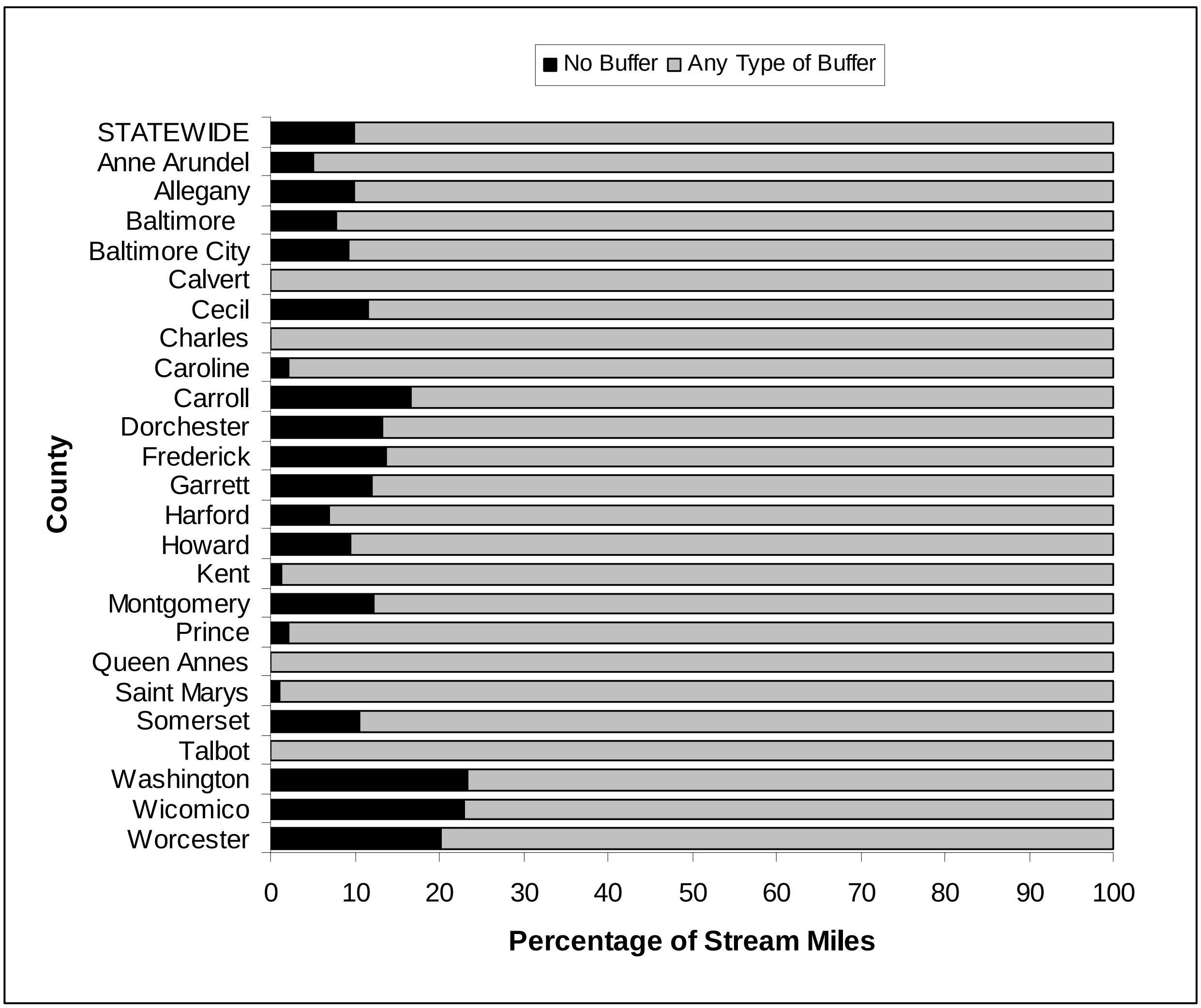

Figure 10-2. Percentage of stream miles having no riparian buffer (both sides of stream) by county, based on data from the 2000-2004 MBSS

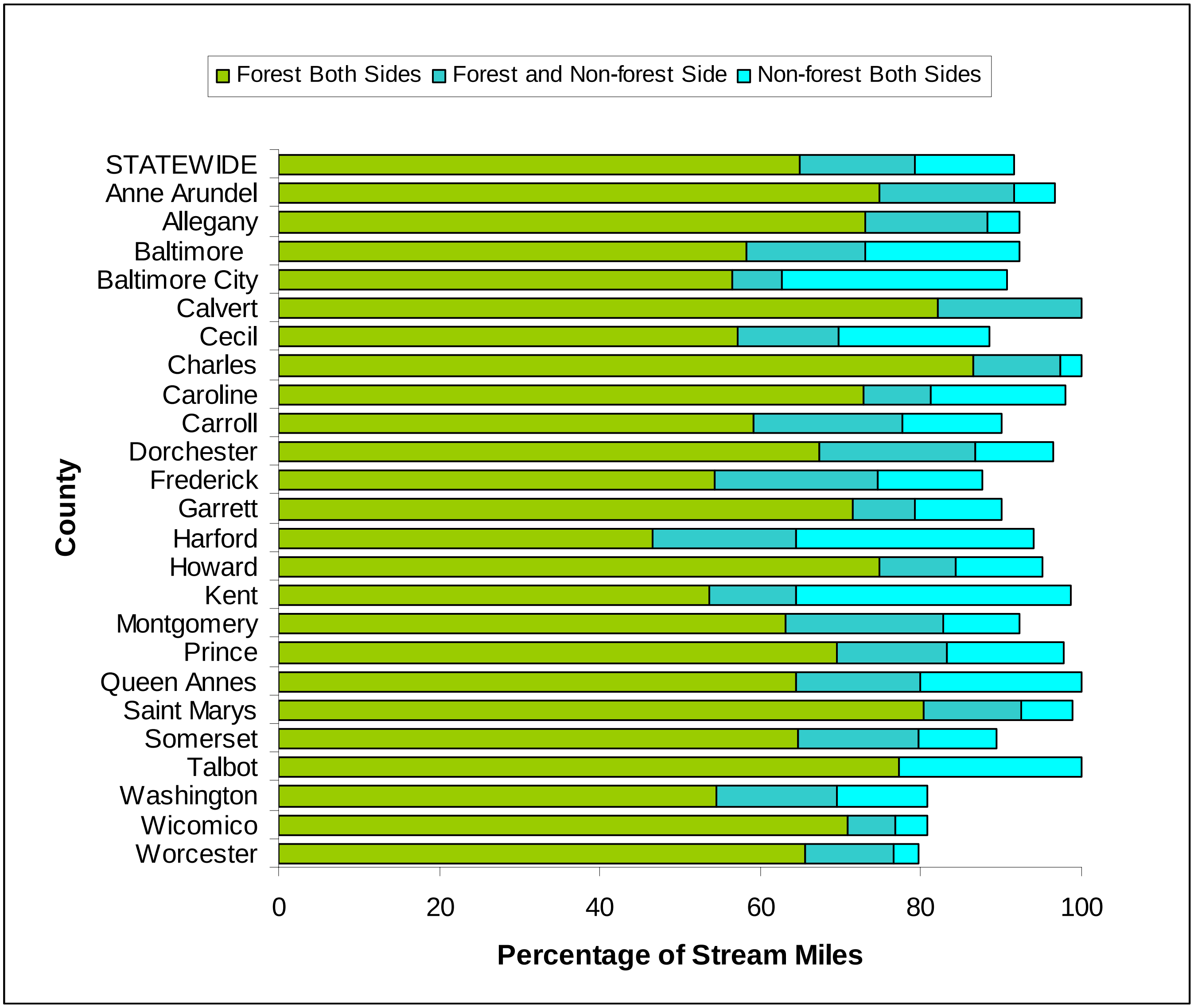

Figure 10-3. Forest and non-forest buffer percentage by one-side and two-sides for Maryland counties

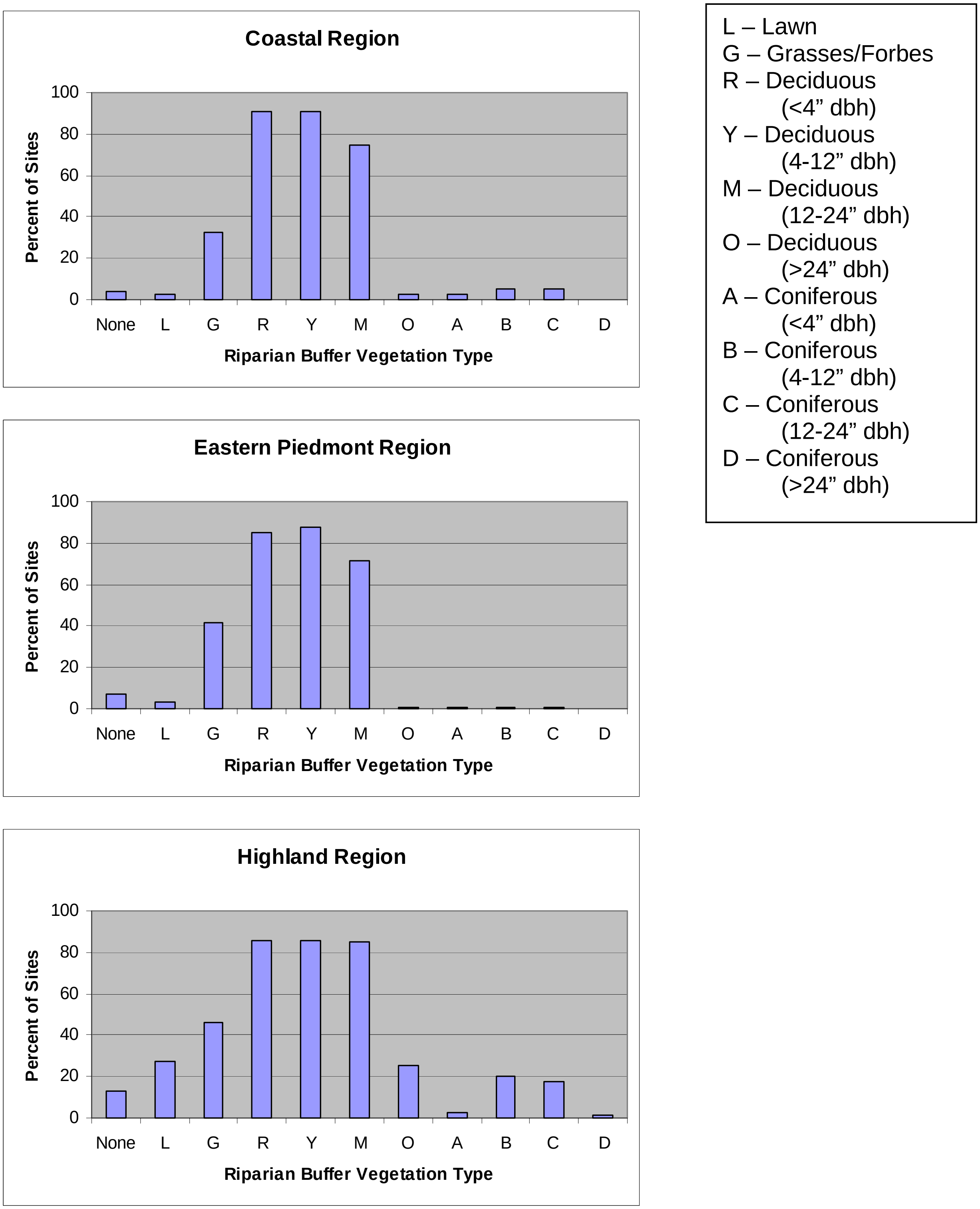

Figure 10-4. Riparian vegetation buffer type by physiographic region in Maryland, based on data from the 2000-2004 MBSS

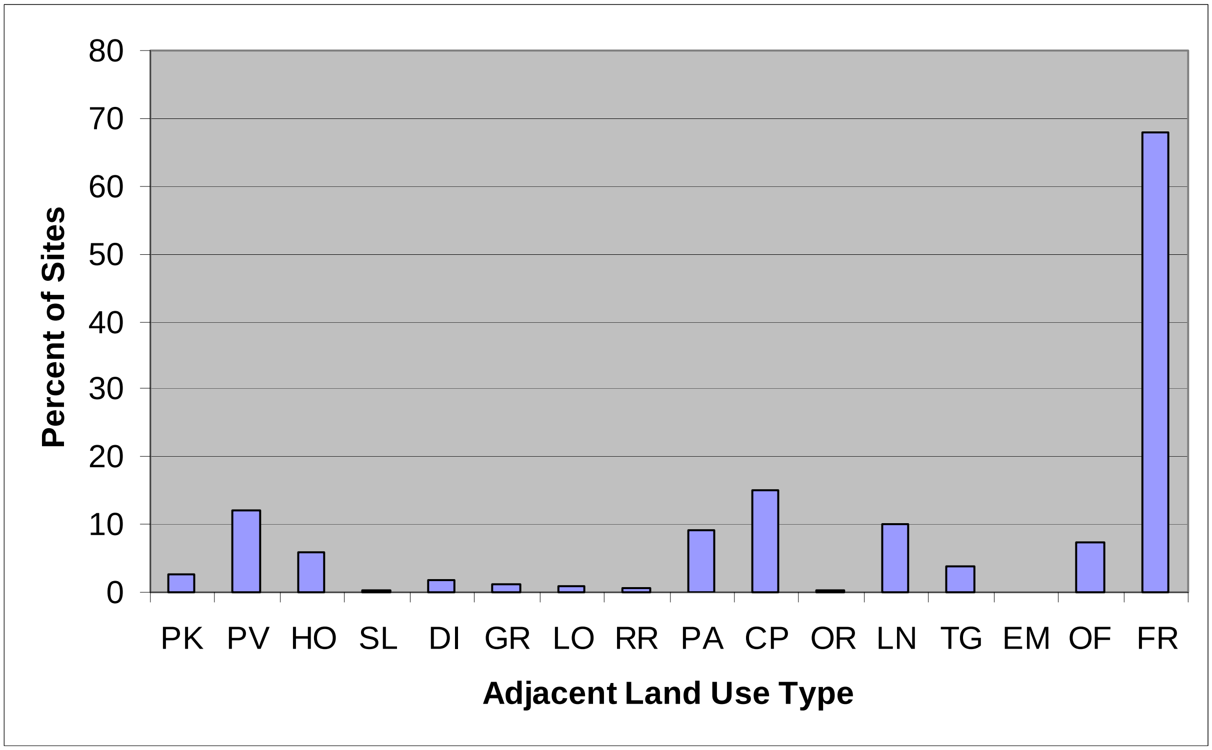

Figure 10-5. Adjacent landuse types present at 2000-2004 MBSS sample stations, statewide (PK=parking lot, PV=paved road, HO=housing, SL=bare soil, DI=dirt road, GR=gravel road, LO=logged area, RR=railroad, PA=pasture, CP=cropland, OR=orchard, LN=lawn, TG=tall grass, EM=emergent vegetation, OF=old field, FR=forest)

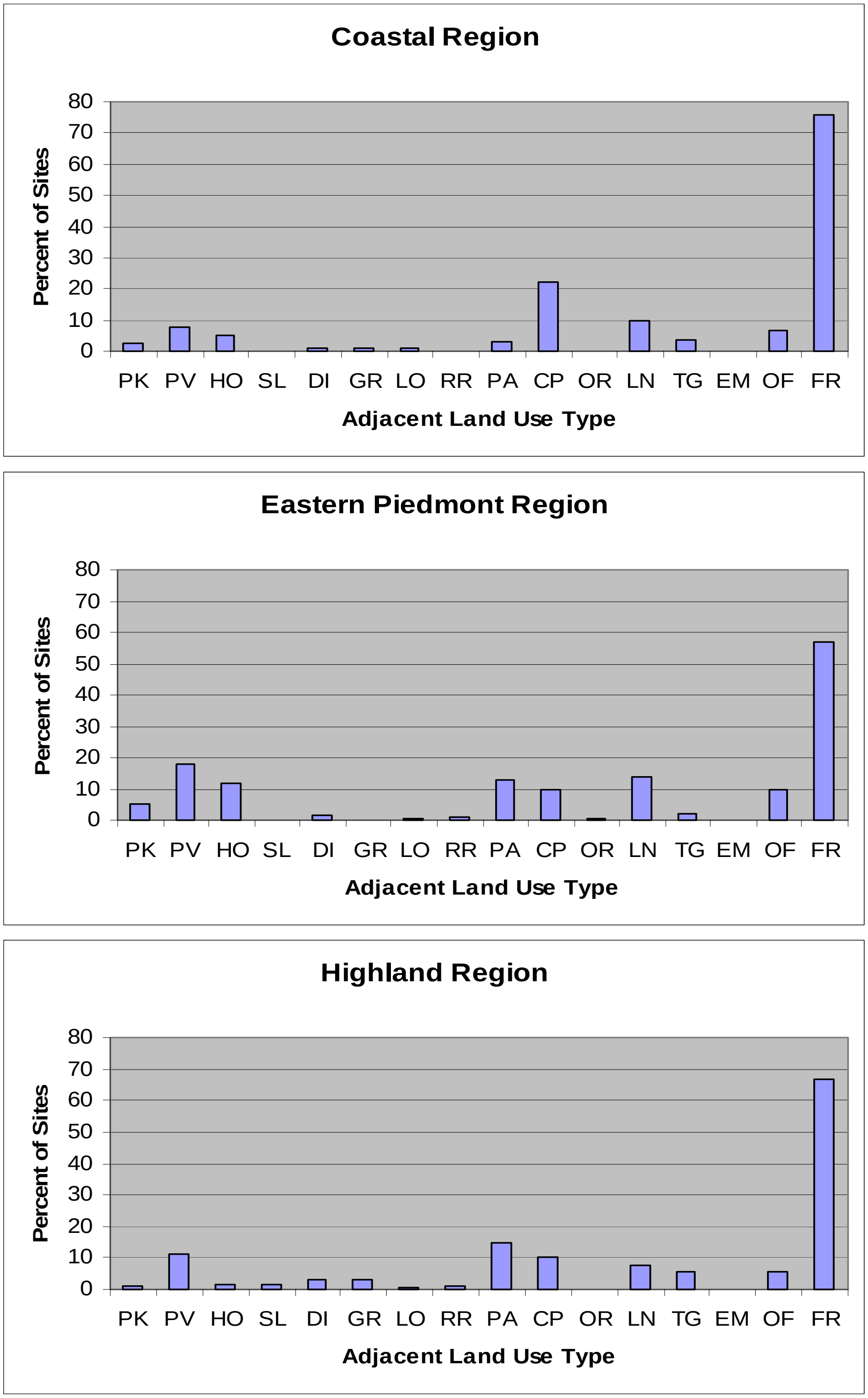

Figure 10-6. Adjacent landuse types present at 2000-2004 MBSS sample stations, by region (PK=parking lot, PV=paved road, HO=housing, SL=bare soil, DI=dirt road, GR=gravel road, LO=logged area, RR=railroad, PA=pasture, CP=cropland, OR=orchard, LN=lawn, TG=tall grass, EM=emergent vegetation, OF=old field, FR=forest)

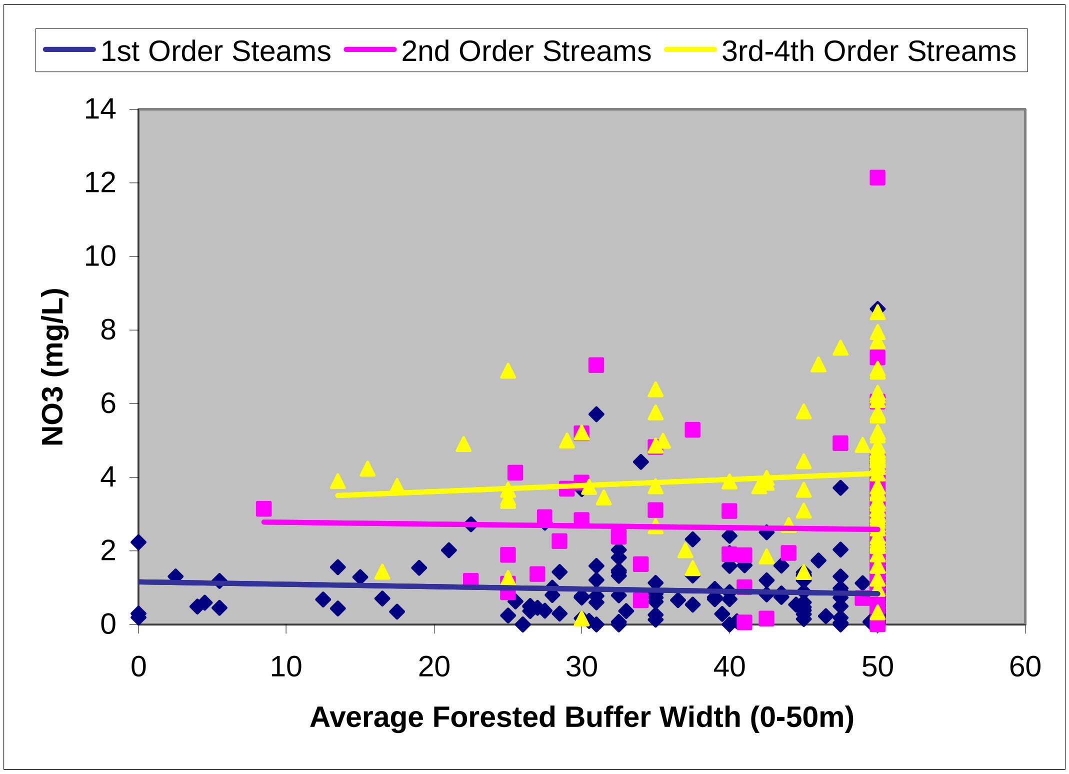

Figure 10-7. Instream nitrate-nitrogen levels at 2000-2004 MBSS sites by forested buffer width and stream order

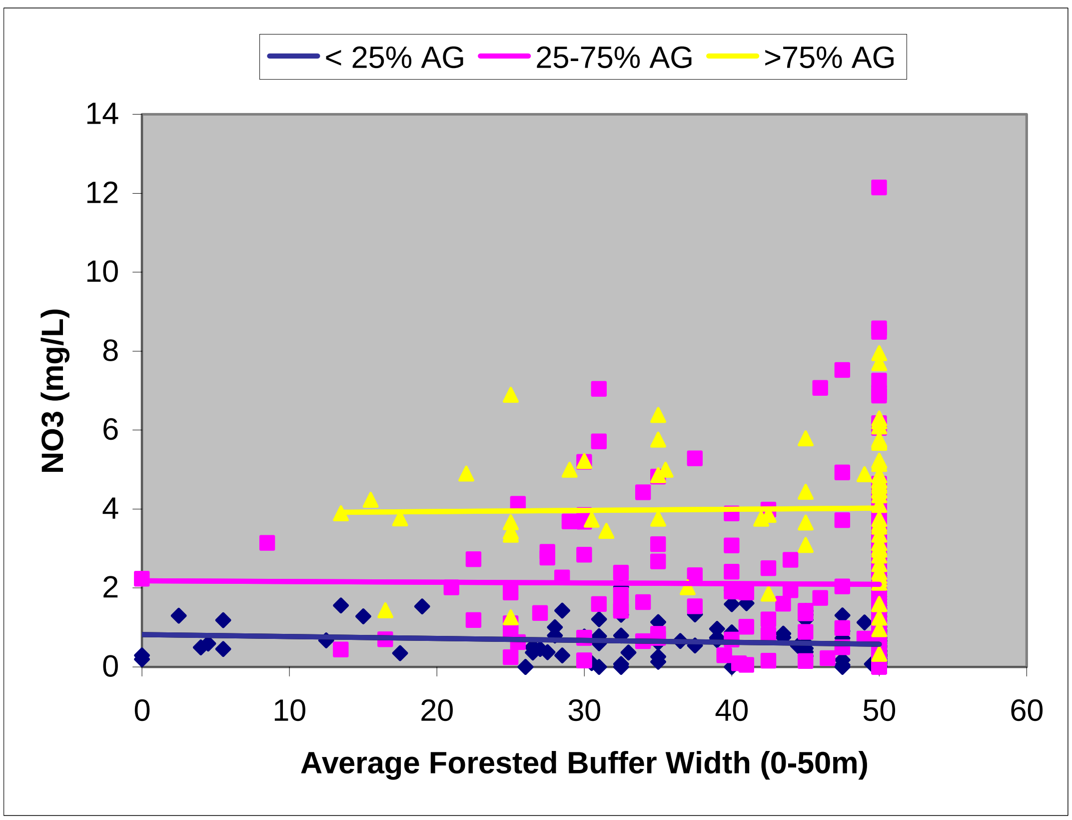

Figure 10-8. Instream nitrate levels at 2000-2004 MBSS sites by extent of agriculture in basin and forested buffer width

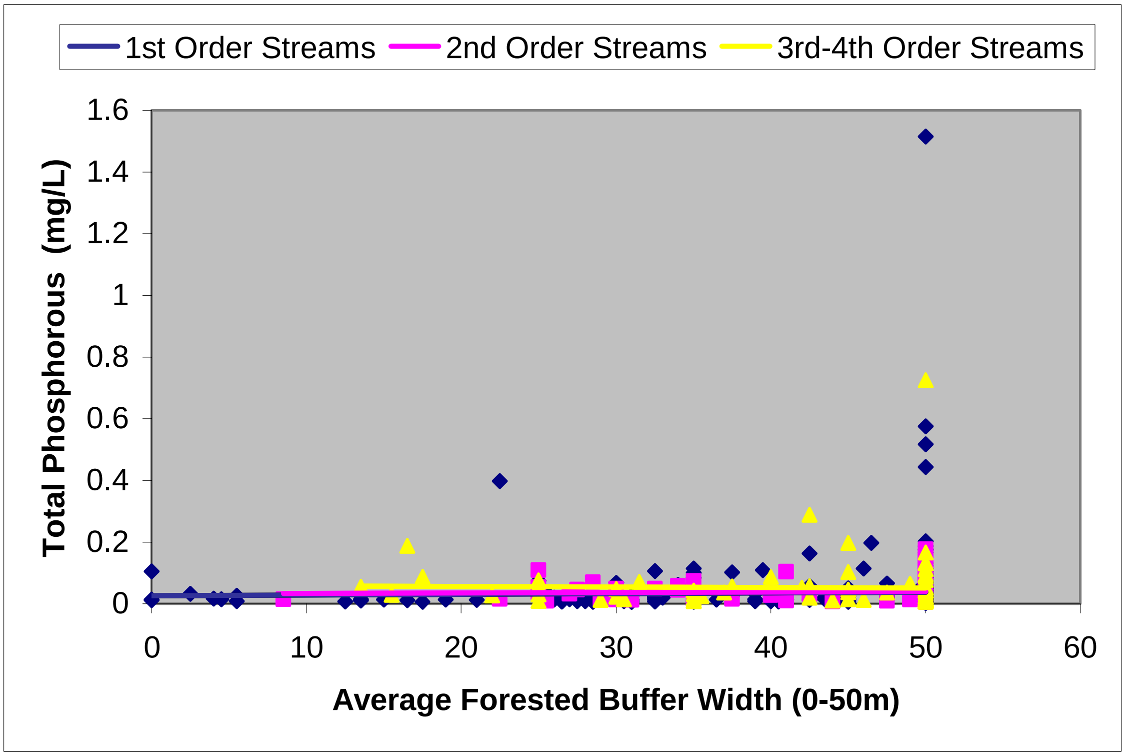

Figure 10-9. Instream total phosphorus at 2000-2004 MBSS sampling sites by forested buffer width and stream order

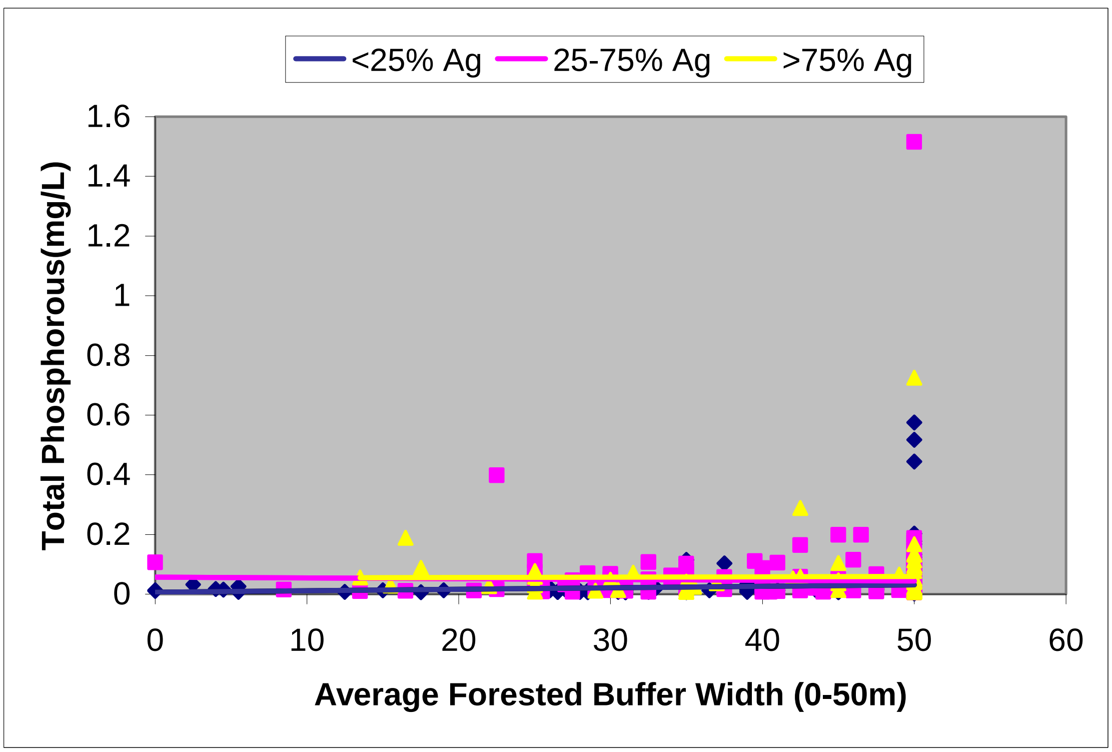

Figure 10-10. Total phosphorus at 2000-2004 MBSS sampling sites by extent of agriculture and forest buffer width

10.3 SHADING

Shading is one of the many important functions of stream buffers. Adequate shading maintains lower stream temperatures. Streams that support brook trout are particularly sensitive to temperature changes since brook trout prefer temperatures below 68 ºF/20 ºC for reproduction and below 75 ºF/23.9 ºC for adult fish. Water temperature also affects general metabolism and nutrient cycling, algal growth rates, and dissolved oxygen concentrations. Thus, alteration of normal temperature regimes can impact aquatic biota in multiple ways.

As part of the MBSS, shading is estimated as a percentage based on the degree and duration of shading at a site during summer, including any effects of shading caused by landforms. Based on results from the 2000-2004 MBSS, most of the randomly selected sample sites were over 80% shaded (Figure 10-11). As expected, smaller streams (first or second order) tended to have a higher percent shading. Shading on third order and larger streams were related to the presence of forest cover in the riparian zone (Figure 10-12; $p< 0.05$, $r^2 = 0.05$), but the variability in tree cover adjacent to the water is great even where buffers were quite wide (50 m). The variability in percent shading in wide buffers is partly explained by the extent of buffer breaks and channel alterations that may create openings even where much of the buffer is predominantly forested. Additionally, some of the forested buffers were dominated by young trees, which would not provide shading over the entire stream width (Figure 10-12).

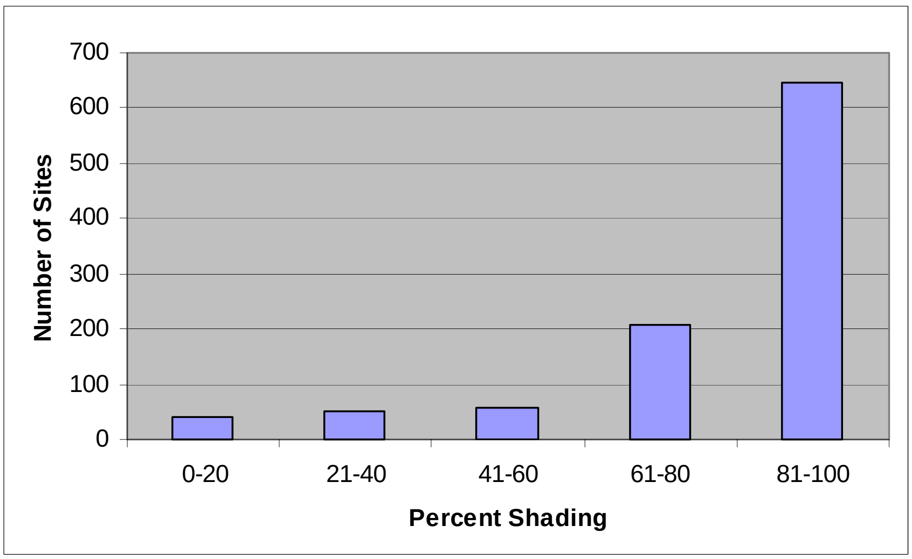

Figure 10-11. Percent shading at 2000-2004 MBSS sample sites, statewide by shade category

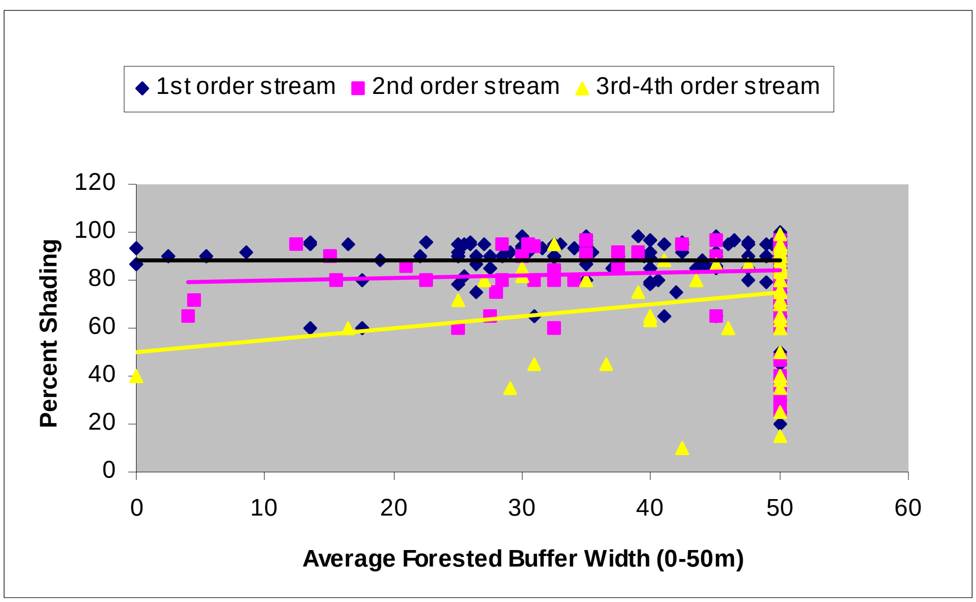

Figure 10-12. Stream shading at 2000-2004 MBSS sites and forested buffer width by stream order, statewide

Statewide, shading averaged 80%, although conditions varied substantially among counties (Figure 10-13, Table 10-1). Most of the counties where average shading fell below 80% were in areas where the dominant land uses are agriculture and urban.

Table 10-1. Average, maximum, and minimum stream shading scores by county

	Shading Score		
County	Mean	Min	Max
Anne Arundel	84	20	99
Allegany	79	25	99
Baltimore	81	5	100
Baltimore City	71	12	97
Calvert	93	70	98
Cecil	74	10	98
Charles	83	15	99
Caroline	83	50	95
Carroll	73	5	98
Dorchester	85	5	97
Frederick	81	30	98
Garrett	79	20	98
Harford	77	7	99
Howard	80	28	95
Kent	73	18	100
Montgomery	84	20	99
Prince George's	85	25	99
Queen Anne's	76	10	96
St. Marys	90	50	100
Somerset	68	10	97
Talbot	97	75	96
Washington	74	10	98
Wicomico	77	10	98
Worcester	69	5	97

10.4 RIPARIAN BUFFER BREAKS

For the purpose of the MBSS, riparian buffer breaks were defined as any break in the riparian buffer zone (e.g., storm drain, tile drain, impervious drainage, gully, orchard, crop, pasture, new construction, dirt road, gravel road, raw sewage, or railroad) where surface runoff could flow directly into the stream channel. Although many MBSS sites during 2000-2004 had riparian buffers that were bordered by forest, there were also many breaks in the buffer (e.g., gullies, impervious drainages, storm/tile drains, and dirt/gravel roads) that effectively limited the ability of the riparian buffer to filter nutrients and maximize the infiltration of runoff. For the MBSS, riparian buffer breaks were categorized and classified as either minor or severe. The most common buffer breaks were pasture and cropland (Table 10-2). These conditions allow some infiltration of runoff to occur and would be expected to generate more nutrients than natural forest. Other frequently found severe breaks included impervious surfaces and storm drains which would preclude any natural treatment as water passed through buffer areas. Although infrequent, instances of suspected raw sewage reaching streams were recorded.

Statewide, 27.6% of the stream miles had some type riparian buffers break. Land used as pasture (7.8%) and drainage from impervious surfaces (4.8%) were the most common buffer break types, statewide. The types and extent of buffer breaks found varied greatly by county (Figures 10-14 and 10-15). Counties where agricultural land use was common (e.g., Carroll, Washington, Worchester, Wicomico) tended to have pastureland and crop areas included in the riparian zone, along with dirt roads. Buffer breaks in more urban counties (e.g., Baltimore County, Baltimore City, Harford, Prince George's) tended to have breaks from storm drains and other impervious drainages, including concrete-lined ditches that are constructed to directly funnel storm water into streams during precipitation events.

Table 10-2. Number of breaks in vegetated buffers by type and classification as minor or severe, based on 2000-2004 MBSS.

Buffer Break Type	# Minor	# Severe
Crop	24	27
Dirt Road	31	12
Gravel Road	22	1
Gully	68	13
Impervious Drainage	62	43
New Construction	3	2
Pasture	65	77
Railroad	8	1
Raw Sewage	0	2
Storm Drain	38	35
Tile Drain	19	2

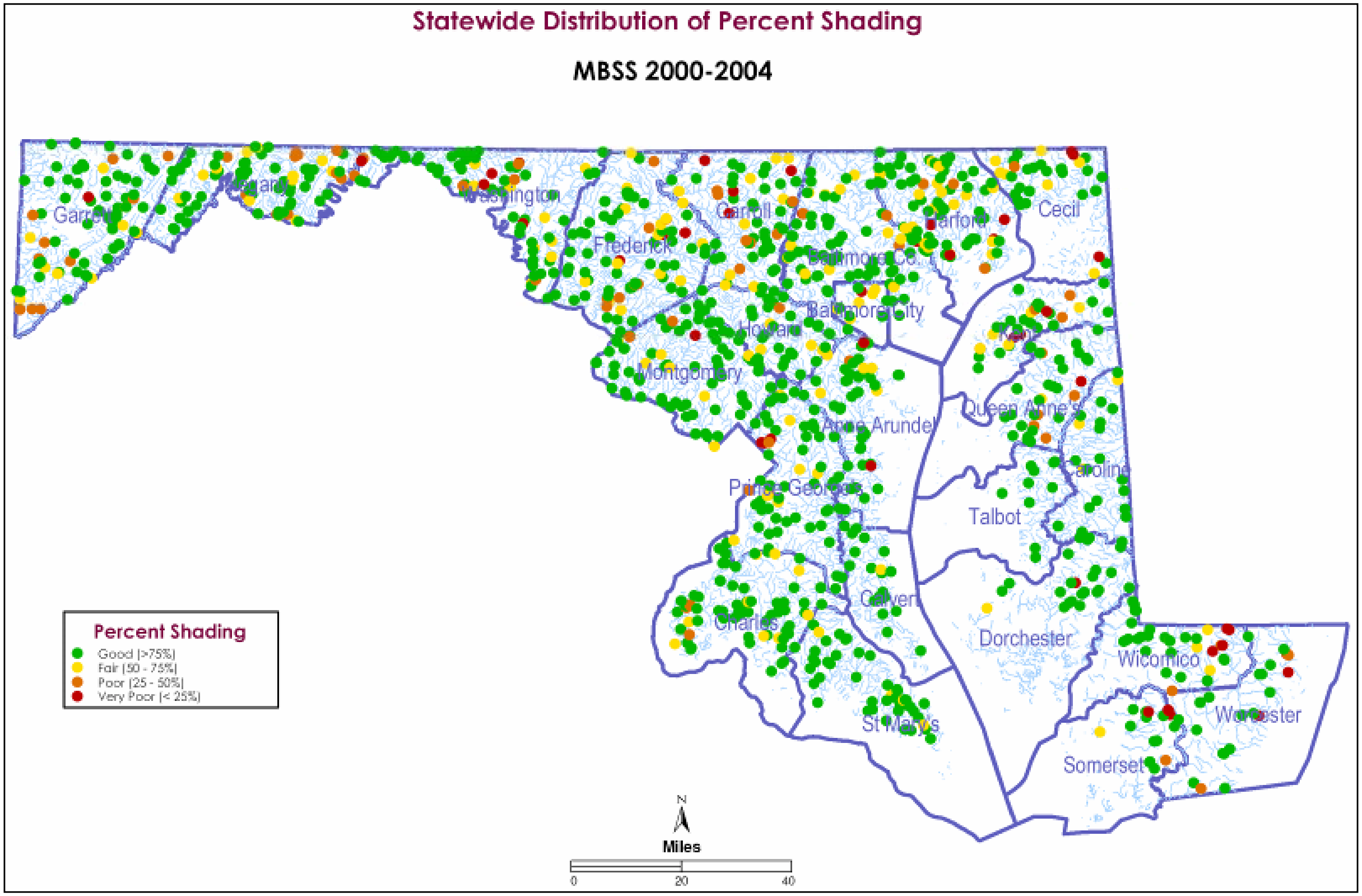

Figure 10-13. Percent shading at 2000-2004 MBSS sample sites

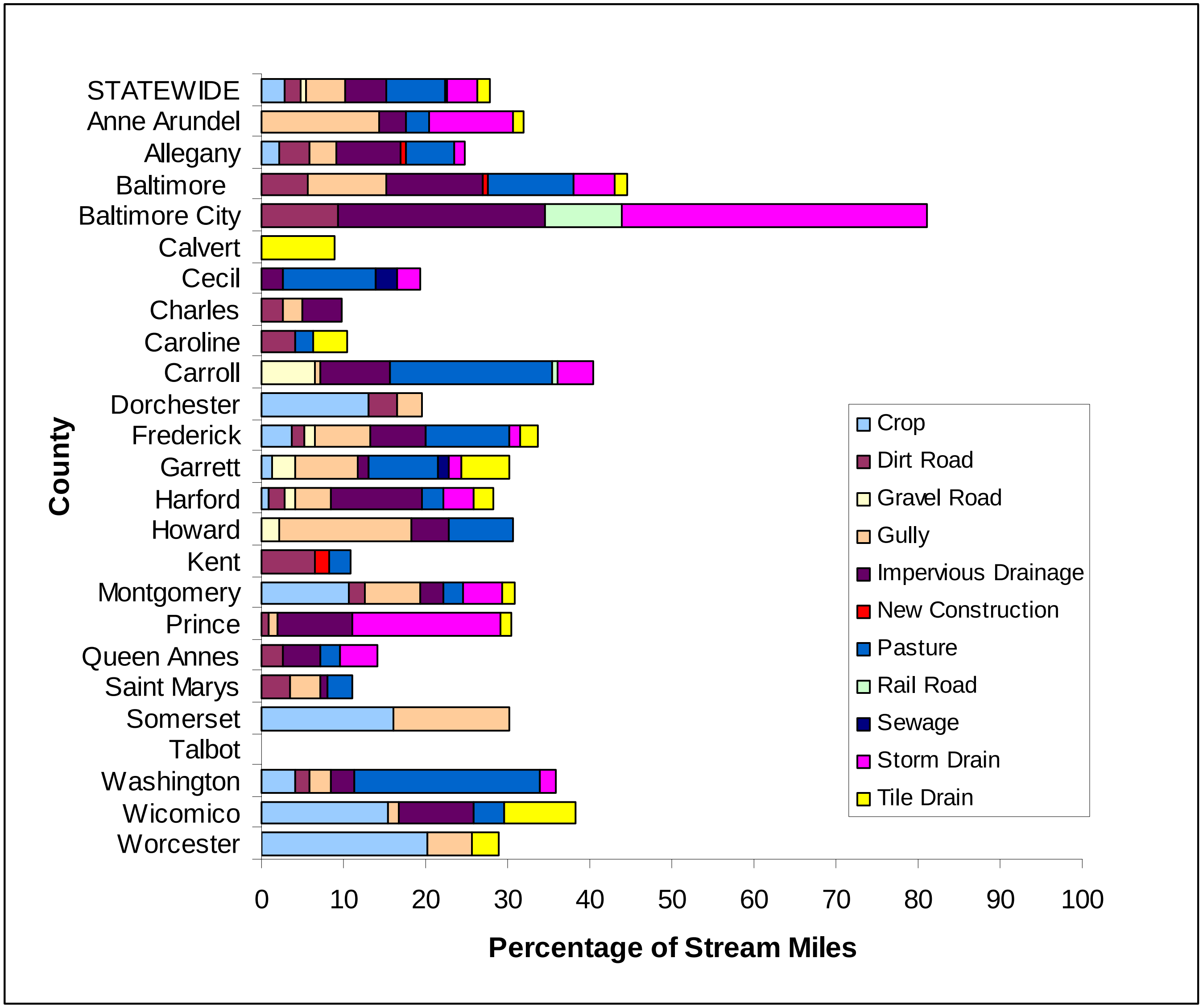

Figure 10-14. Percentage of stream miles with breaks in buffer vegetation, by category of buffer break and Maryland county statewide at 2000-2004 MBSS sample sites

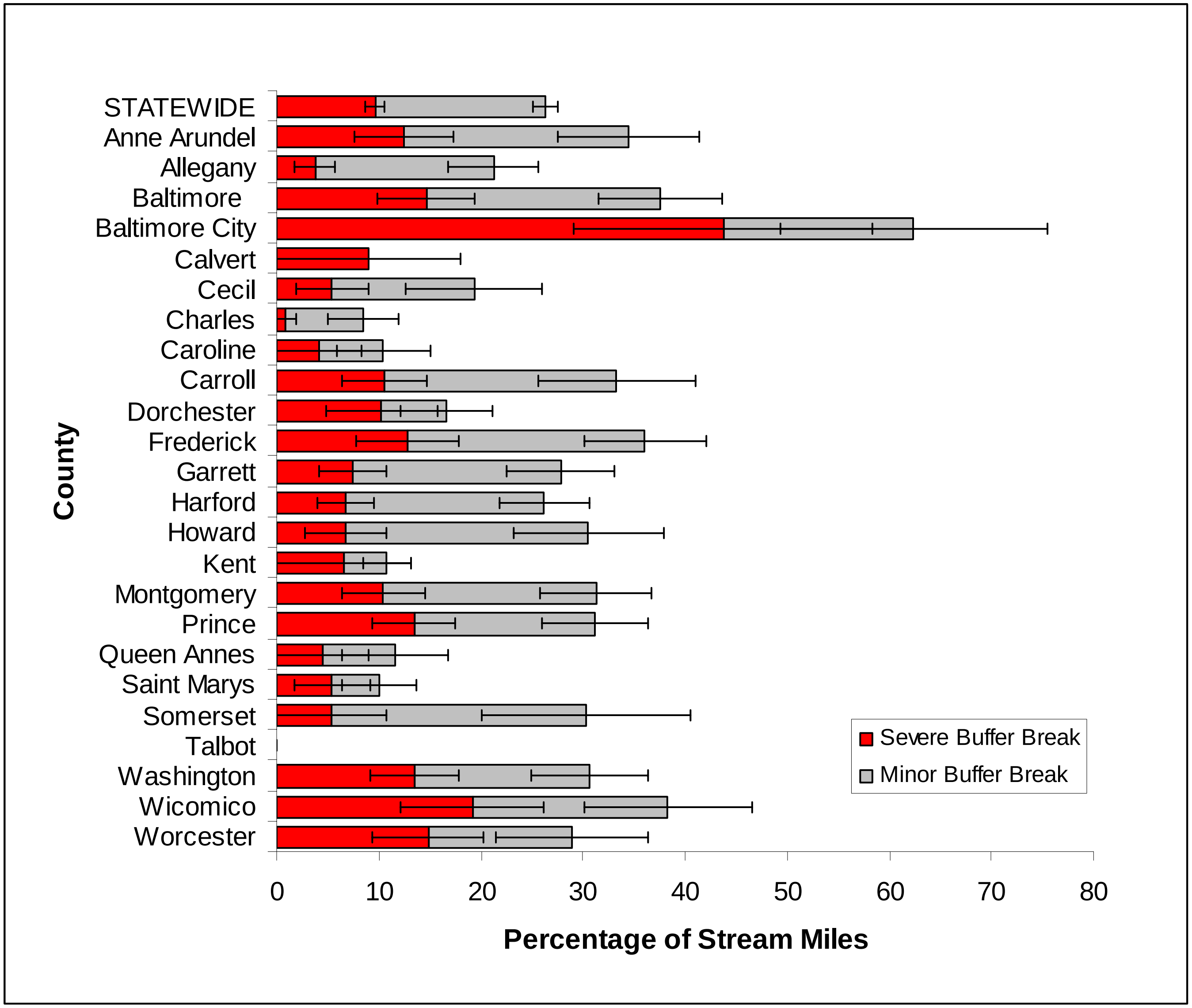

Figure 10-15. Percentage of stream miles with breaks in buffer vegetation, by severity and Maryland county

10.5 RIPARIAN BUFFERS AND CHANNELIZATION

In addition to alterations of the riparian zone, channelization can also significantly alter the natural character of streams. In agricultural and rural areas, streams are channelized to drain fields and to provide flood control and/or drain wetlands. Streams in urban areas are channelized primarily to allow road building and to quickly evacuate stormwater from impervious surfaces.

Natural streams offer aquatic habitat and efficient capture of nutrients. These functions are generally reduced with channel alterations. When previously meandering streams are straightened and incised, they typically lose their natural connection to the floodplain. Without the interaction of stream and floodplain, nitrogen filtration is usually reduced and changes in the forest community can occur as a result of the drier soils in the floodplain (Groffman et. al., 2004). Habitat complexity is also typically reduced, and the combination results in significant negative consequences to stream biota.

Based on results from the 2000-2004 MBSS, the most common type of channel alteration was earthen ditching, found at an estimated 11% of all sites. Ditches and the earthen berms that often accompany the ditches affect surface runoff and also the connectivity of riparian habitat. Concrete channels (5%) and rip-rap (5%) were the next most common types of channelization observed (Figure 10-16). Concrete channels typically have minimal habitat value, isolate the stream from both the riparian area and shallow groundwater, and are highly efficient at conveying nutrients and organic matter downstream. In contrast, rip-rap channelization consists of large boulders placed along stream banks to prevent erosion during high runoff events. Rip-rap does not always exert a negative impact on streams, sometimes providing habitat for fish and macroinvertebrates as well as stabilizing stream banks. However, artificial armoring of stream banks impedes natural channel processes and can create additional habitat problems downstream. Gabion baskets can provide aquatic habitat, but problems occur when they break down (Fischenich 2003).

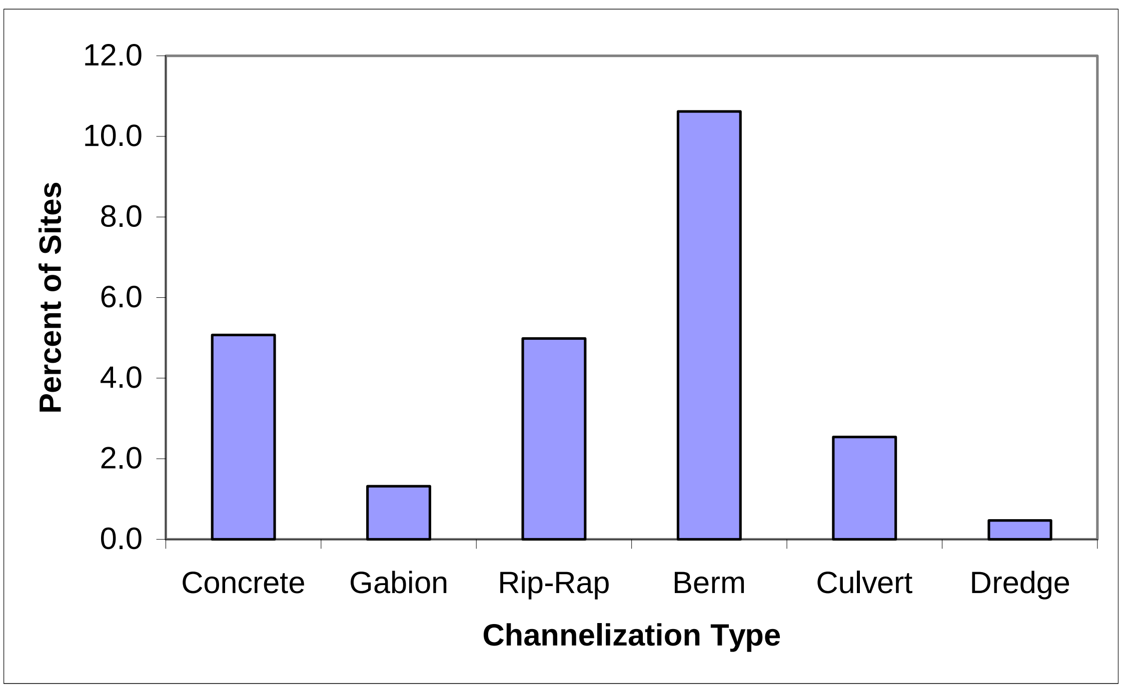

Figure 10-16. Percentage of sample sites where channel alteration was observed, statewide at 2000-2004 MBSS sample sites

10.6 INVASIVE PLANTS

Invasive exotic plants are species that tend to spread rapidly and displace native vegetation from their normal habitats. While any vegetation can be used as ground cover to prevent erosion, native species are preferred for their ability to provide natural habitats, accommodate species-specific life history and diet requirements. Native insects and animals evolved with local vegetation and some aquatic species require specific native plants to complete their life cycle. While most riparian buffer zones do not exclusively consist of invasive species, their presence in large numbers clearly diminishes the diversity and health of the stream community and changes the quality and quantity of wildlife habitat available. Some invasive species have been found to allow greater leaching of nitrogen, another trait that diminishes efforts to maintain natural buffer functions (Kourtev et. al. 1999).

Disturbed riparian areas are particularly prone to invasive species, for several reasons. Seeds from upstream may be deposited in canopy openings created by flooding, logging, or other disturbances. Additionally, plants that spread primarily by vegetative means (root or shoot sprouts), rather than by seed, can spread extensively along a stream corridor. Invasive plant species often have a life history strategy that exploits new habitat rapidly, thus invasives do well in disturbed areas where the slower to establish native vegetation can be out competed.

Invasive plants were observed in riparian areas at most (85%) of the 2000-2004 MBSS sample sites (Table 10-3, Figure 10-17). While invasive plant species were present at many of the sample sites, extensive growth was recorded at less than 20% of all sites. Invasive plant species were present at nearly every sample site in counties in central Maryland where urbanization and agriculture are widespread. In these areas, stream flooding and disturbance is often greatest, and a wide variety of sources of invasive plants is available. It should be noted that the upland distribution of the same species may differ from the riparian distribution, even within a region, so the estimates from the riparian area should not be extrapolated.

10.6.1 Multiflora Rose (***Rosa multiflora***)

Multiflora rose is native to Japan, Korea, and Eastern China and was introduced to the eastern U.S. in 1866 as rootstock for ornamental roses (Wyman 1949)). It has been promoted for use as living livestock fences, erosion control, and cover for wildlife. Multiflora rose has been planted in median strips to serve as crash barriers and to reduce glare caused by oncoming traffic. Multiflora rose grows quickly and out competes most native herbs and shrubs. It is designated as an invasive pest species by several states, including Iowa, Ohio, New Jersey, Pennsylvania, and West Virginia. Multiflora rose occurs in Washington, Oregon, and throughout the eastern U.S. (US NPS 2004). The distribution of multiflora rose covers the entire state of Maryland and is extensive throughout the central counties (Figure 10-18).

10.6.2 Mile-a-Minute (***Polygonum perfoliatum***)

Mile-a-minute is native to India, Eastern Asia, and the islands from Japan to the Philippines. It was first established in the U.S. in the 1930s in York County, Pennsylvania. Mile-a-minute successfully takes over open and disturbed areas such as fields, forest edges, stream banks, wetlands, and roadsides. This invasive plant species is found in the northeastern U.S. from Virginia to New York to Ohio and is also found in Oregon (US NPS 2004). Mile-a-minute was present at 2000-2004 sample sites in every county except Garrett in far Western Maryland and in Dorchester, Worcester, and Caroline counties on the Lower Eastern Shore (Figure 10-19). The distribution of mile-a-minute is extensive throughout the Eastern Piedmont region of Maryland.

10.6.3 Japanese Honeysuckle (***Lonicera japonica***)

Japanese honeysuckle is native to Eastern Asia and was introduced in the U.S. in the 1800s (Leatherman 1955). This exotic plant has been used as an ornamental, for erosion control, and for wildlife cover and food. Japanese honeysuckle is present in at least 38 states from New England to the southern and midwestern states to California. It is an evergreen plant and is thus able to grow when most native plants are dormant. Its vigorous growth can smother native plants and shrubs (US NPS 2004). Japanese honeysuckle was present at 2000-2004 sample sites in every county except Garrett in far western Maryland and was very widespread in areas east of Washington County (Figure 10-20).

10.6.4 Common Reed (***Phragmites australis***)

Common reed is a tall grass, the invasive subspecies of which was introduced from Europe. It is an invasive plant that displaces native plants in aquatic habitats including brackish and freshwater marshes, riverbanks, lakeshores, ditches, and dredge spoil areas. It spreads by seed, has extensive thick roots, and once established, is difficult to control. Cutting, burning, and herbicides have all been used to control this invasive plant (US NPS 2004). Common reed was found at only 3% of the MBSS sample sites statewide during the 2000-2004 MBSS and in every county on the eastern shore except Talbot (Figure 10-21).

Table 10-3. Invasive species occurrence and extent in riparian areas by Maryland counties, based on 2000-2004 MBSS data.

County	Multiflora Rose	Mile-a-minute	J. Honeysuckle	Phragmites	Thistle	Microstegium	Any Species
STATEWIDE	69% (8%)*	26% (2%)	61% (3%)	3% (0%)	13% (0%)	39% (7%)	85% (18%)
Anne Arundel	65% (4%)*	21.1% (0%)	60% (40%)	6% (0%)	8% (0%)	30% (4%)	87% (12%)
Allegany	65% (1%)	8.4% (0%)	17% (0%)	1% (0%)	20% (0%)	33% (2%)	73% (3%)
Baltimore	99% (22%)	54.8% (5%)	89% (8%)	3% (0%)	18% (1%)	63% (15%)	100% (37%)
Baltimore City	67% (0%)	16.7% (0%)	83% (0%)	0% (0%)	0% (0%)	25% (0%)	92% (0%)
Calvert	50% (6%)	0% (0%)	50% (6%)	0% (0%)	0% (0%)	56% (05)	83% (6%)
Cecil	96% (7%)	42.9% (0%)	75% (0%)	4% (0%)	11% (0%)	82% (18%)	100% (25%)
Charles	43% (3%)	5.9% (0%)	63% (3%)	4% (0%)	1% (0%)	44% (2%)	78% (7%)
Caroline	62% (0%)	4.8% (0%)	57% (0%)	14% (5%)	0% (0%)	44% (0%)	71% (5%)
Carroll	98% (21%)	63% (4%)	79% 92%)	0% (0%)	29% (0%)	69% (17%)	100% (31%)
Dorchester	50% (0%)	4% (0%)	71% (0%)	8% (0%)	0% (0%)	21% (0%)	75% (0%)
Frederick	82% (29%)	16% (2%)	47% (4%)	0% (0%)	35% (0%)	44% (6%)	90% (31%)
Garrett	20% (0%)	0% (0%)	0% (0%)	0% (0%)	13% (2%)	8% (0%)	33% (2%)
Harford	91% (13%)	60% (8%)	85% (4%)	4% (0%)	16% (1%)	81% (11%)	99% (30%)
Howard	98% (12%)	76% (5%)	76% (0%)	0% (0%)	17% (0%)	89% (44%)	100% (34%)
Kent	83% (3%)	17% (0%)	77% (0%)	9% (0%)	9% (0%)	57% (9%)	94% (11%)
Montgomery	95% (9%)	58% (2%)	75% (2%)	0% (0%)	20% (0%)	71% (29%)	100% (39%)
Prince George's	75% (9%)	30% (2%)	88% (8%)	2% (0%)	4% (0%)	37% (9%)	95% (23%)
Queen Anne's	48% (0%)	3% (0%)	74% (0%)	10% (0%)	3% (0%)	38% (0%)	87% (0%)
Saint Mary's	17% (2%)	2% (0%)	57% (5%)	0% (0%)	0% (0%)	53% (0%)	69% (7%)
Somerset	41% (0%)	6% (0%)	65% (6%)	6% (0%)	6% (0%)	47% (0%)	82% (6%)
Talbot	70% (0%)	10% (0%)	50% (0%)	0% (0%)	10% (0%)	13% (0%)	80% (0%)
Washington	70% (5%)	2% (0%)	25% (0%)	0% (0%)	27% (4%)	52% (7%)	88% (14%)
Wicomico	49% (11%)	6% (0%)	57% (0%)	6% (0%)	3% (0%)	13% (0%)	74% (11%)
Worcester	25% (0%)	0% (0%)	70% (0%)	5% (0%)	5% (0%)	20% (0%)	85% (0%)

* Value in parentheses is percent of sites were species was extensive

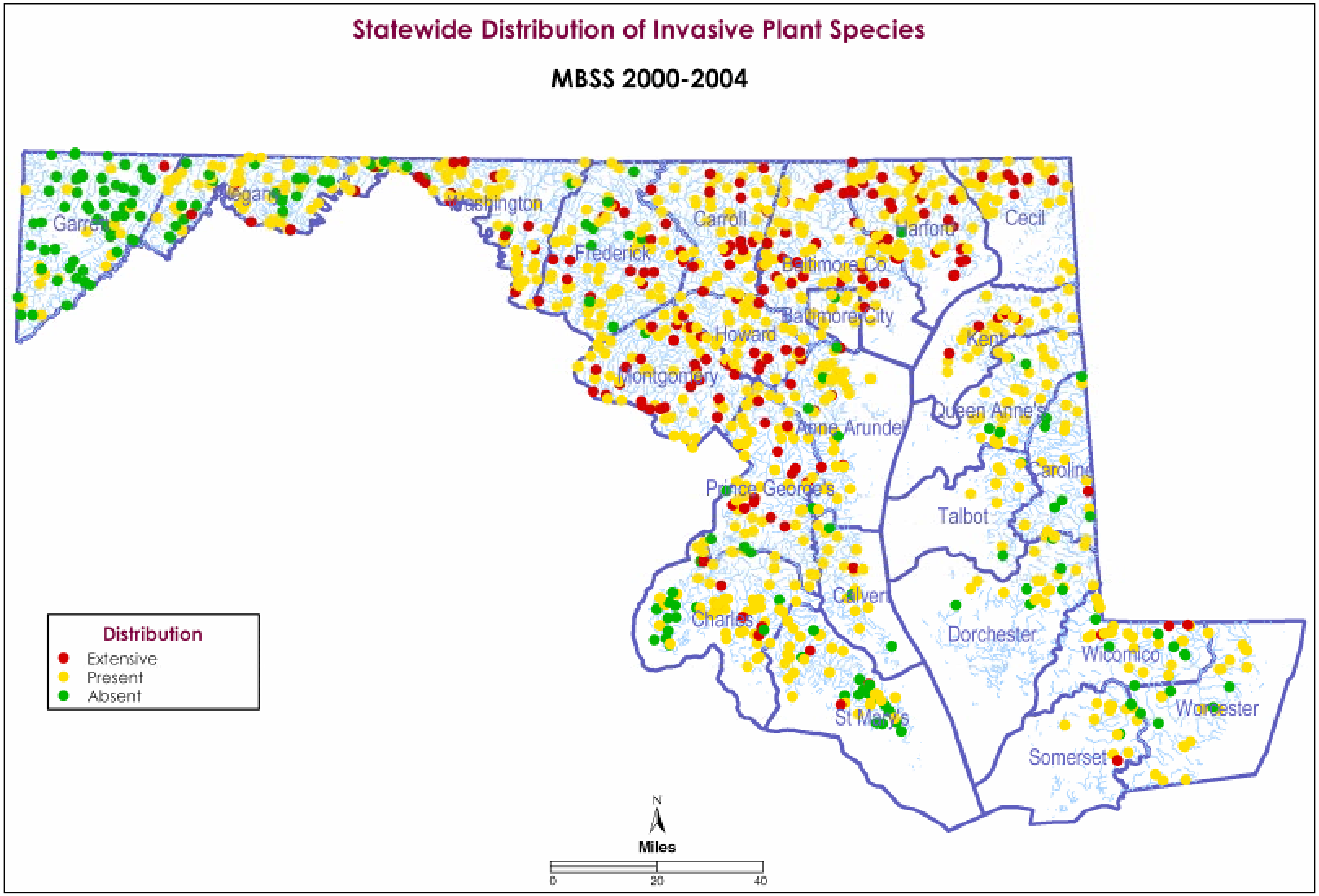

Figure 10-17. Statewide distribution of 2000-2004 MBSS sample sites where any invasive plant species was absent, present, or extensive within the streamside riparian areas

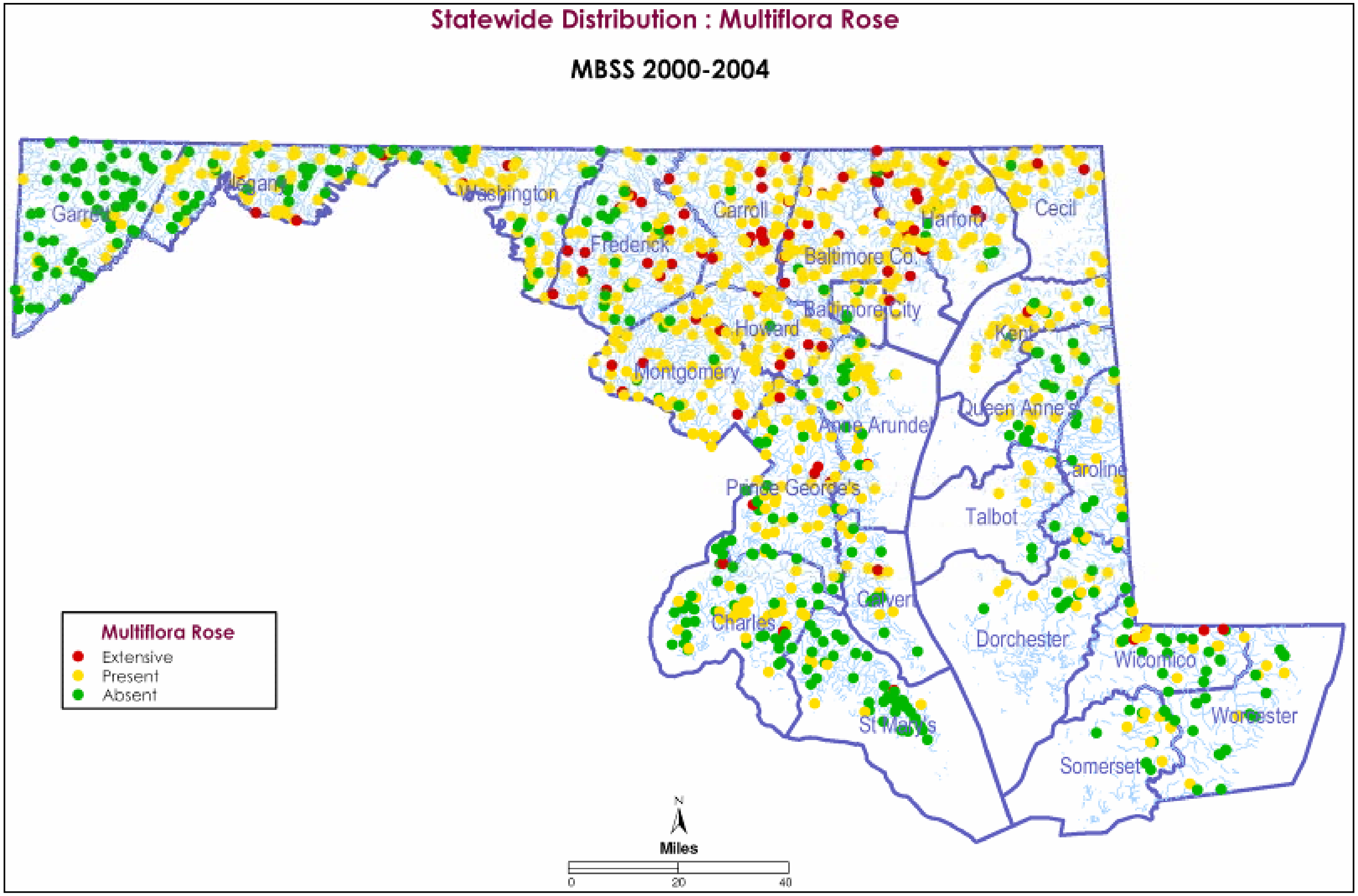

Figure 10-18. Statewide distribution of multiflora rose at 2000-2004 MBSS sample sites within the streamside riparian areas

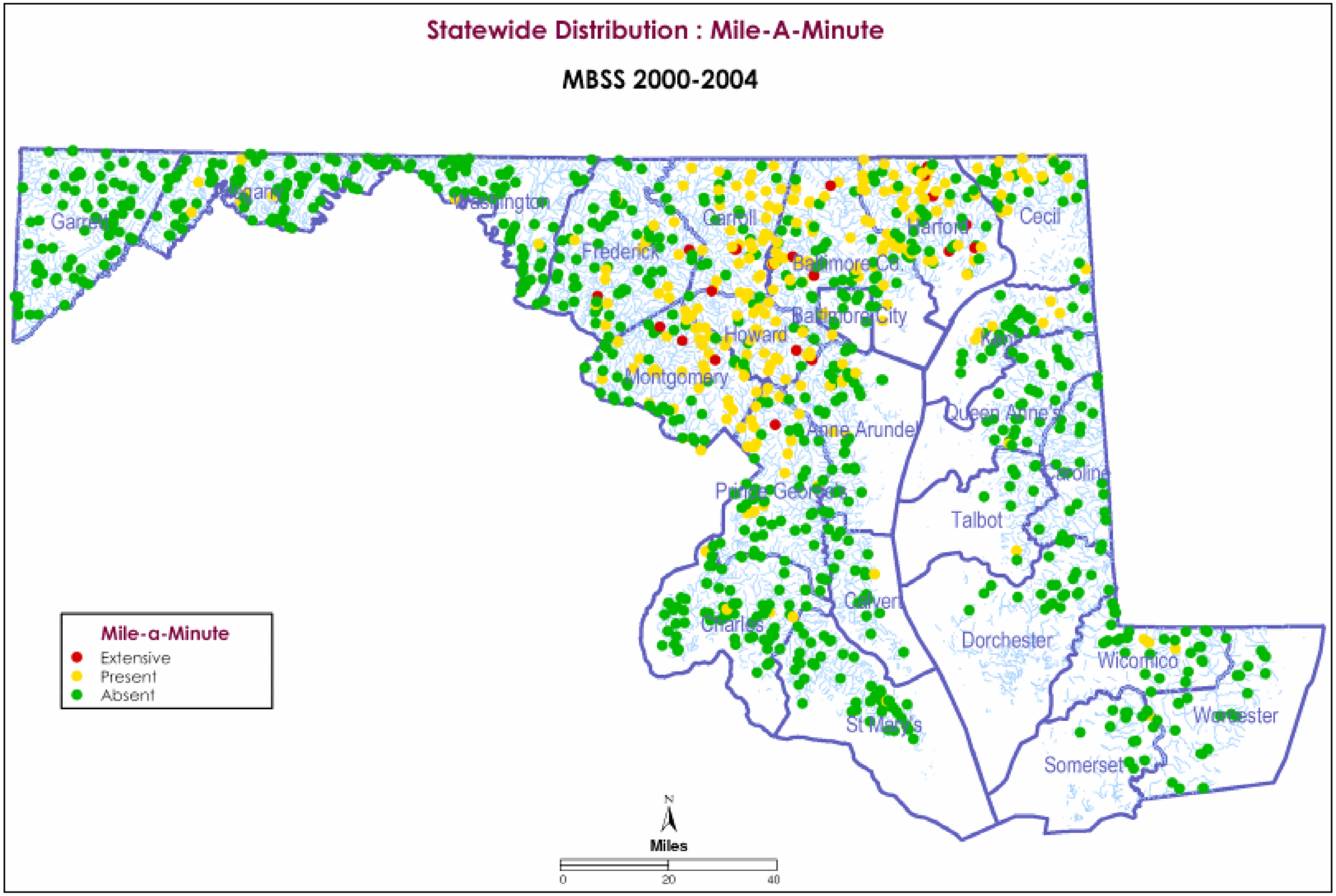

Figure 10-19. Statewide distribution of mile-a-minute at 2000-2004 MBSS sample sites within the streamside riparian areas

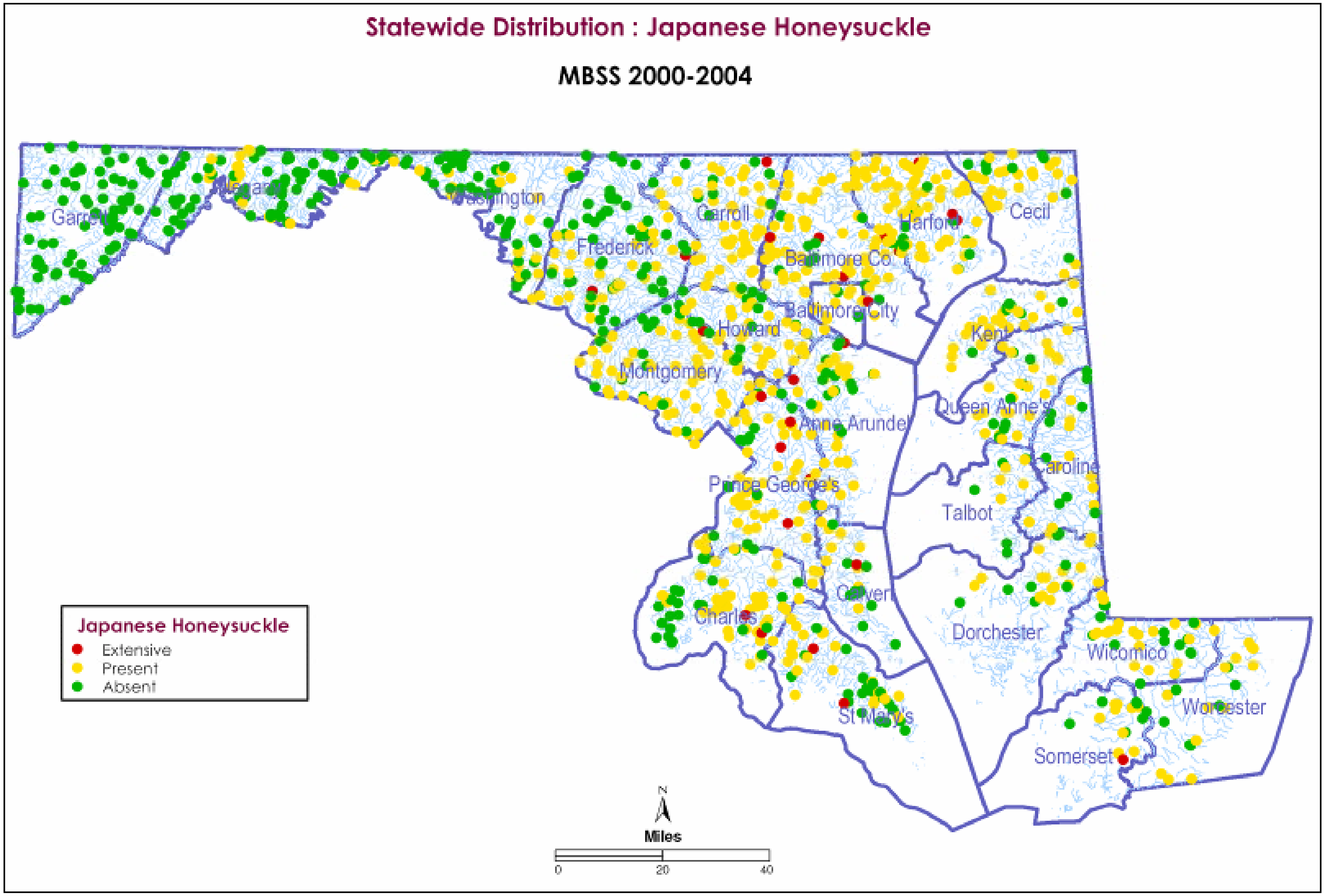

Figure 10-20. Statewide distribution of Japanese Honeysuckle at 2000-2004 MBSS sample sites within the streamside riparian areas

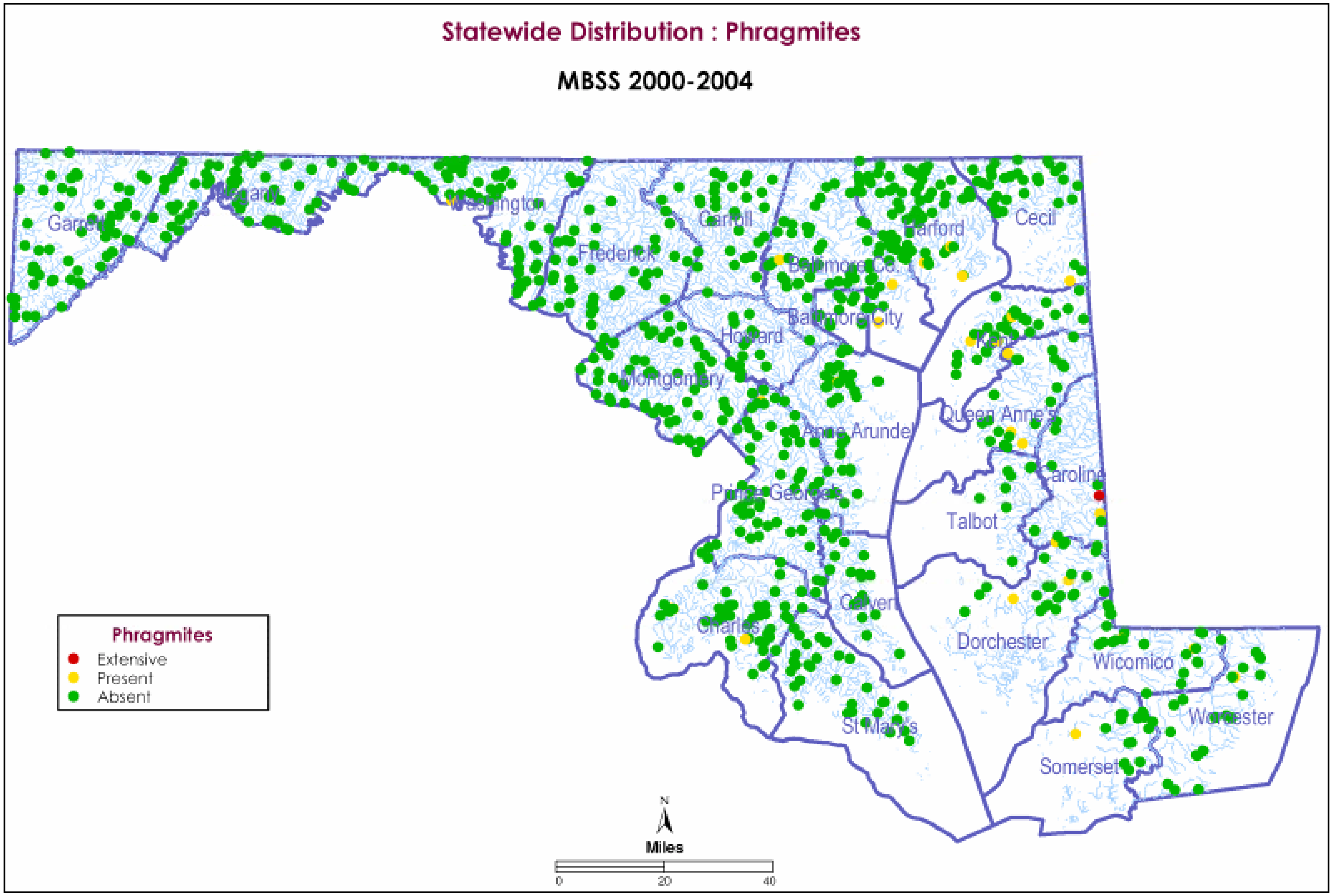

Figure 10-21. Statewide distribution of Common Reed (Phragmites) at 2000-2004 MBSS sample sites within the streamside riparian areas

10.6.5 Japanese Stilt Grass (***Microstegium vimineum***)

Japanese stilt grass is native to Japan, Korea, China, Malaysia, and India. It was introduced into the U.S. in Tennessee around 1919 (Tu 2000). It is believed that it was introduced as a result of its use as packing material for porcelain. Japanese stilt grass competes with understory vegetation in all areas from full sun to heavy shade. It can be found in most habitats including stream banks, river bluffs, floodplains, wetlands, moist forested areas, early successional fields, uplands, thickets, roadside ditches, gas and power lines, and in lawns and gardens. In the United States, Japanese stilt grass is currently established in 16 states from New York to Florida (US NPS 2004). It was present at 2000-2004 sample sites in every county in Maryland (Figure 10-22). The distribution of Japanese stilt grass is extensive throughout the Eastern Piedmont region of Maryland.

10.6.6 Canada Thistle (***Cirsium arvense***)

Canada thistle is native to the temperate regions of Eurasia. It was introduced to the United States as early as the 1600s (Hansen 1918) and is designated as a noxious weed in 43 states. Canada thistle inhabits dry to moist areas including barrens, fields, glades, pastures, stream banks, moist meadows, and wet prairies. This invasive plant occurs in dense patches and displaces native plant species, reducing biodiversity (US NPS 2004). Canada thistle was found at 13% of the 2000-2004 MBSS sample sites and was most common in riparian areas in Frederick, Carroll, and Montgomery counties (Figure 10-23).

10.7 WOODY DEBRIS

Woody debris is a natural source of habitat diversity in streams. Wood, live or dead, that lies outside of the wetted stream channel can still be highly functional. This “de-watered woody debris” provides shade and cover for aquatic organisms and can provide flow refuge during flooding events that fill the channel and submerge the otherwise exposed wood. De-watered woody debris also provides the potential for future instream woody debris. Woody debris that falls into a stream channel promotes the formation of aquatic habitats such as pools and eddies (Hilderbrand et al. 1997) and increases channel and habitat complexity (Keller and Swanson 1979; Fausch and Northcote 1992), which provide numerous habitats for fish and macroinvertebrates (Angermeier and Karr 1984; Benke et al. 1984; Dolloff 1986; Bisson et al. 1987; O’Connor 1990), and promotes storage of sediments and organic materials (Keller and Swanson 1979; Swanson et al. 1982). Woody debris also functions as an important interface linking terrestrial and aquatic environments (Triska and Cromack 1980).

To assess the availability of woody debris as habitat at MBSS sample sites, the number of de-watered and instream woody debris and rootwads that were present within the 75-m sample segments was recorded. De-watered woody debris and rootwads were counted if they were located within the stream bankfull channel but were not in the wetted area of the stream and therefore were not providing usable habitat for aquatic organisms. Statewide, the mean number of instream woody debris was 4.0 per 75 m sample site (Figure 10-24, Table 10-4). The greatest amount was found in the Nanticoke basin (13.3), which was more than double the mean number found in any other basin. Other basins that had mean values of at least 5.0 per site included the Patuxent River (5.6), Chester River (5.7), and Lower Potomac River (6.2) basins. The lowest mean values were recorded in the Ocean Coastal (1.4), Middle Potomac (1.6), and Susquehanna (1.9) basins. Statewide, the mean number of de-watered woody debris was 5.5, with the greatest amount again being found in the Nanticoke River basin (11.7). Other basins with at least 7.0 pieces per sample site included the North Branch Potomac (7.0) and Patuxent River (7.2) basins.

Statewide, the mean number of instream rootwads was 2.4 per 75-m sample site (Figure 10-24, Table 10-4). The greatest amount was found in the Nanticoke basin (12.1), which was more than three times the mean number found in any other basin. Statewide, the mean number of de-watered rootwads was 5.7. The Ocean Coastal basin had the fewest with 1.4 instream rootwads per sample site.

Statewide, the fish index of biotic integrity (FIBI) scores increased with increasing woody debris; ($p < 0.0005$, $r^2 = 0.02$). FIBI scores in the Coastal Plain tended to increase with increases in woody debris (Figure 10-25; $p < 0.0002$, $r^2 = 0.03$). In these low gradient, alluvial channels, large woody debris is often one of the few sources of habitat diversity in the system. FIBI scores also increased with increasing amounts of woody debris in the Piedmont region (Figure 10-26; $p < 0.0002$, $r^2 = 0.04$). FIBI scores were not significantly related to woody debris amounts in the higher gradient streams of the Highland region, where alternative large cobble and boulder habitats are common (Figure 10-27).

As with FIBI scores, total fish abundance increased with increasing numbers of woody debris statewide ($p < 0.04$, $r^2 = 0.01$). The relationship was strongest in 1st order streams ($p < 0.04$, $r^2 = 0.01$). This positive relationship between fish abundance and woody debris was also present in the 1st order streams of the Coastal Plain ($p < 0.0001$, $r^2 = 0.01$) and Piedmont ($p < 0.05$, $r^2 = 0.05$) regions. Fish abundance had no significant relationship with woody debris amounts in the Highlands region.

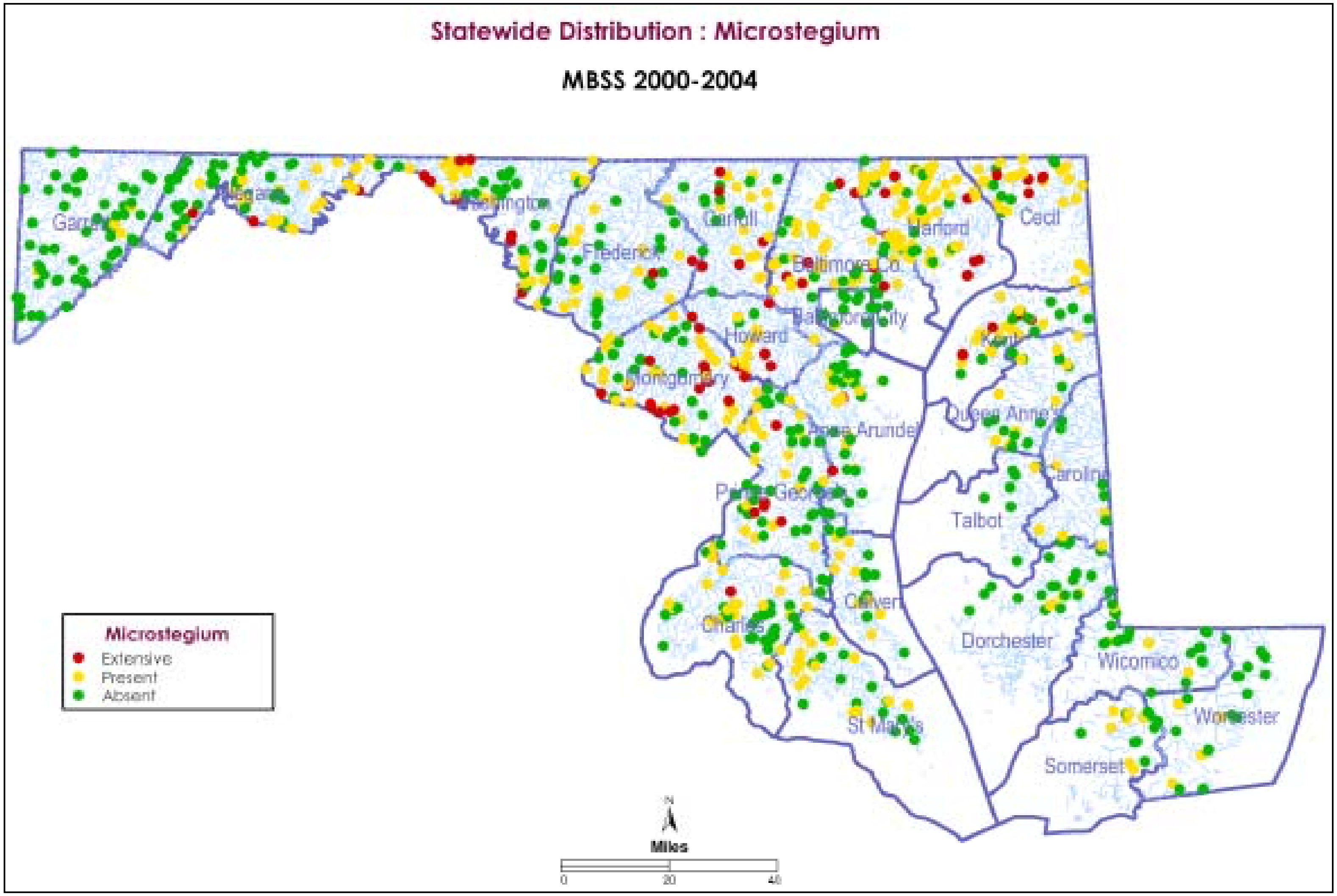

Figure 10-22. Statewide distribution of Japanese stilt grass at 2000-2004 MBSS sample sites within the streamside riparian areas

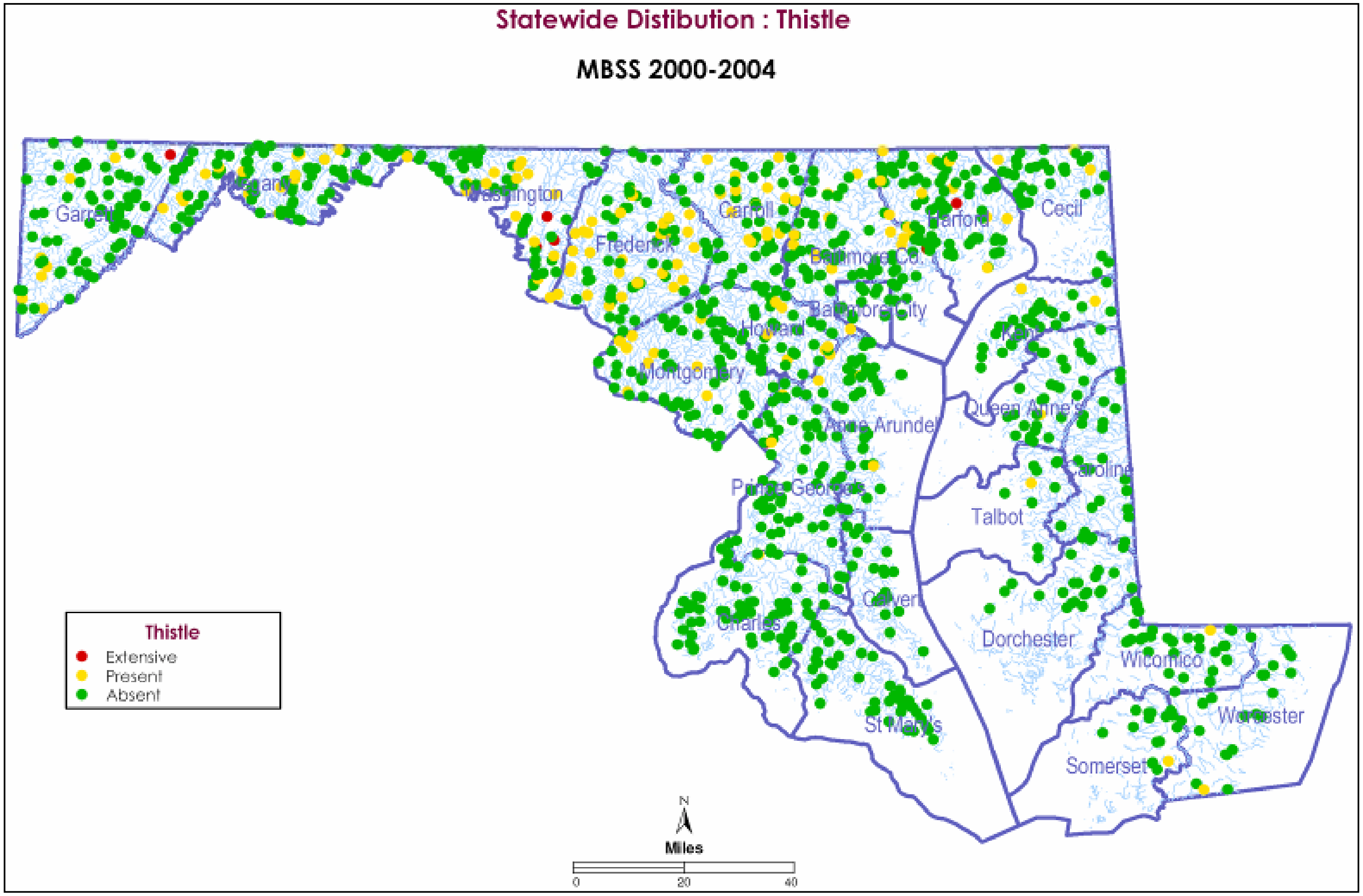

Figure 10-23. Statewide distribution of thistle at 2000-2004 MBSS sample sites within the streamside riparian areas

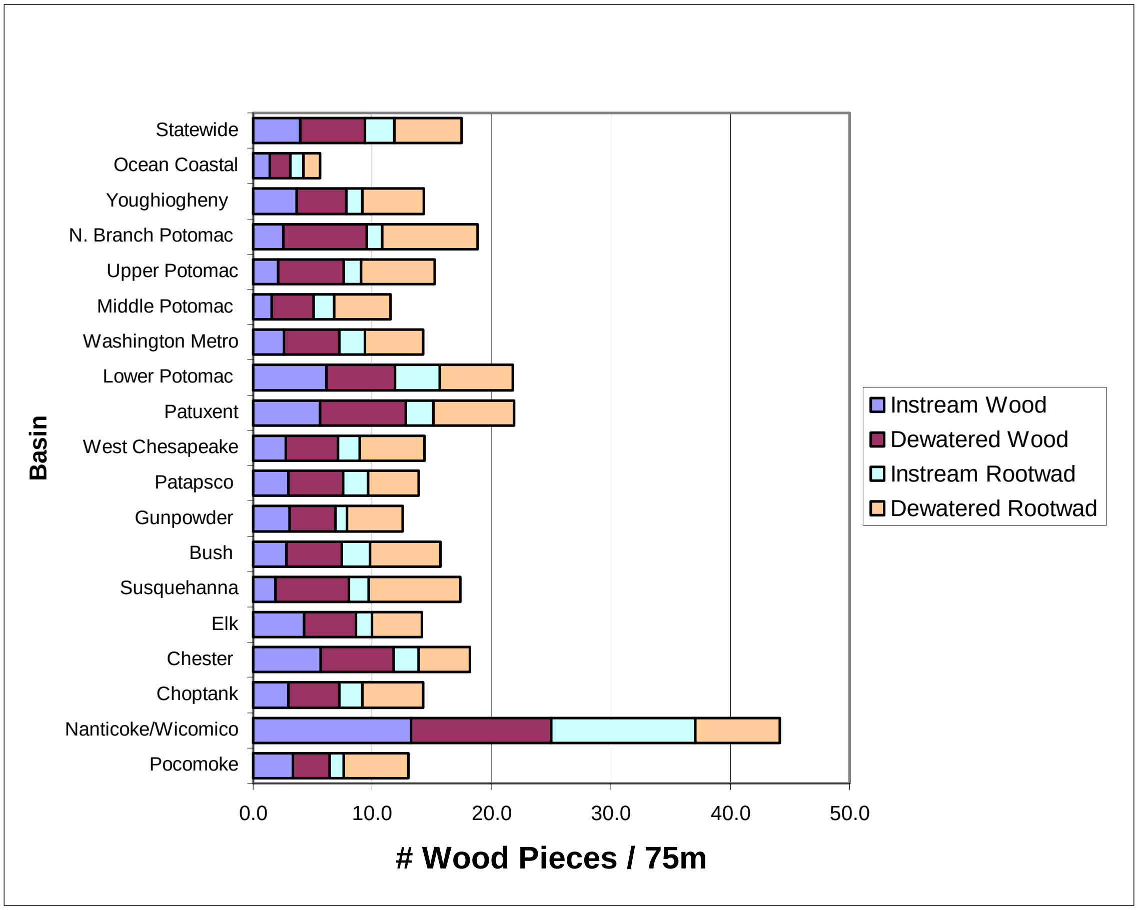

Figure 10-24. Mean number of large woody debris and rootwads at 2000-2004 MBSS sample sites, statewide and by basin

Table 10-4. Mean number of woody debris pieces and rootwads found in the stream channel at 2000-2004 MBSS sample sites, statewide and by basin.

Basin	Instream Woody Debris	De-Watered Woody Debris	Instream Rootwads	De-Watered Rootwads
Pocomoke	3.3	3.2	1.2	5.5
Nanticoke/Wicomico	13.3	11.7	12.1	7.1
Choptank	3.0	4.3	1.9	5.1
Chester	5.7	6.1	2.1	4.3
Elk	4.3	4.3	1.3	4.2
Susquehanna	1.9	6.2	1.7	7.6
Bush	2.8	4.7	2.3	5.9
Gunpowder	3.1	3.8	1.0	4.6
Patapsco	3.0	4.6	2.1	4.3
West Chesapeake	2.8	4.4	1.8	5.4
Patuxent	5.6	7.2	2.4	6.8
Lower Potomac	6.2	5.7	3.7	6.1
Washington Metro	2.5	4.7	2.1	4.9
Middle Potomac	1.6	3.5	1.7	4.7
Upper Potomac	2.1	5.5	1.5	6.2
N. Branch Potomac	2.5	7.0	1.3	8.0
Youghiogheny	3.6	4.2	1.3	5.2
Ocean Coastal	1.4	1.8	1.1	1.4
Statewide	4.0	5.5	2.4	5.7

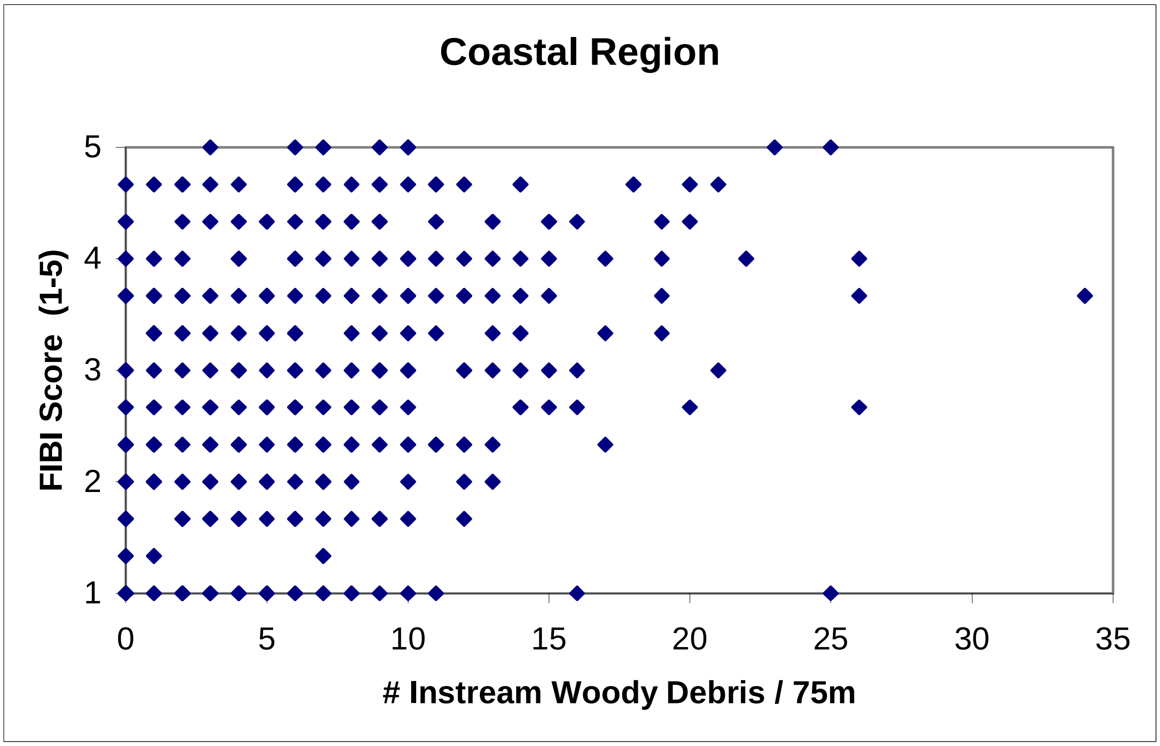

Figure 10-25. Relationship between the FIBI and instream wood at 2000-2004 MBSS sampling sites in the Maryland Coastal Plain ($p<0.0002$, $r^2=0.03$).

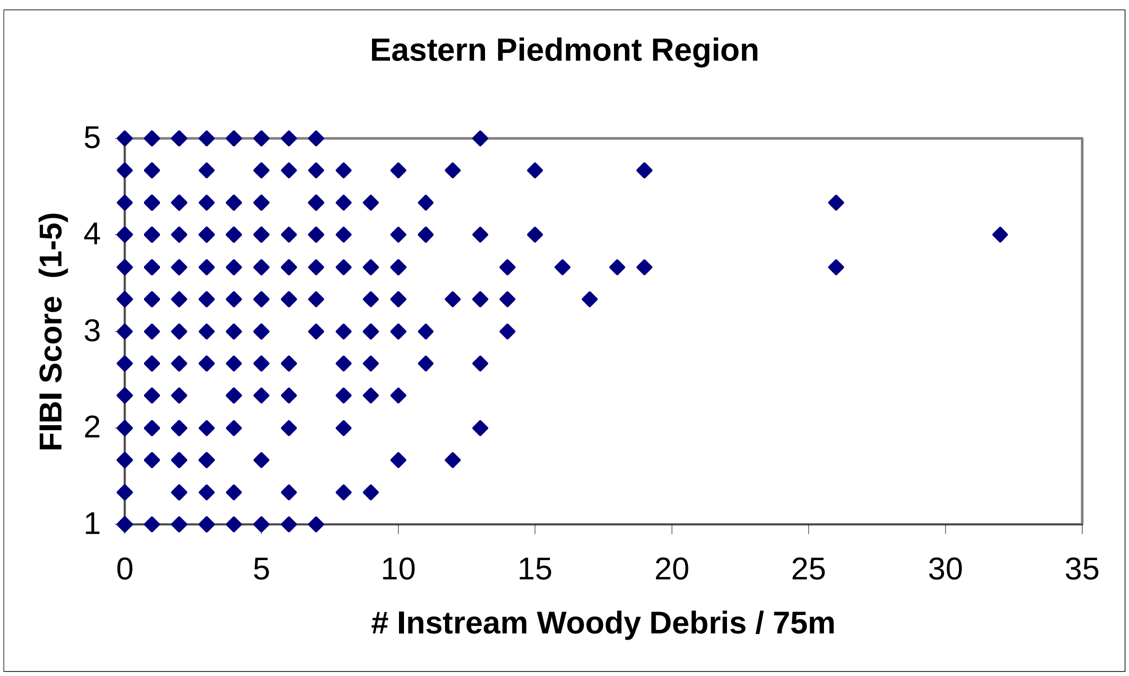

Figure 10-26. Relationship between the FIBI and instream wood at 2000-2004 MBSS sampling sites in the Maryland Eastern Piedmont region ($p<0.0002$, $r^2 = 0.04$).

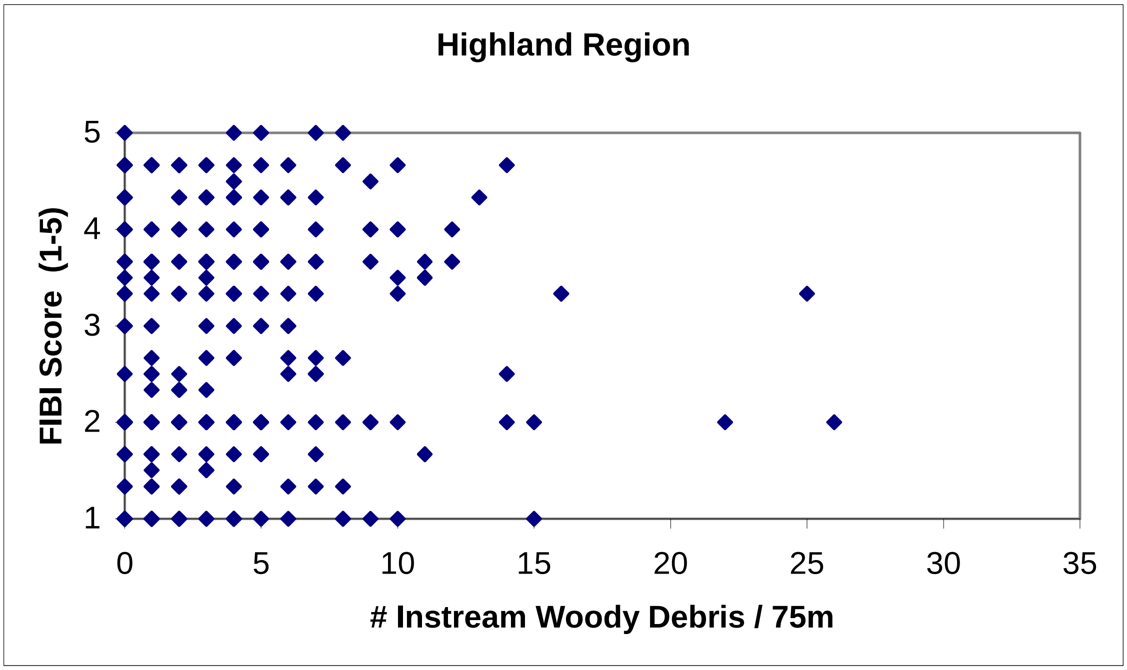

Figure 10-27. Relationship between the FIBI and instream wood at 2000-2004 MBSS sampling sites in the Maryland Highland region.

Analysis of the relationship between the benthic macroinvertebrate index of biotic integrity (BIBI) and the amount of woody debris showed a weak positive relationship statewide ($p < 0.06$) (Figure 10-28) and in the Coastal region ($p < 0.07$). No relationship was present between these two variables in the Piedmont or Highland regions, indicating that other physical and chemical factors play a more substantial role in determining the biological integrity of macroinvertebrate communities in these areas.

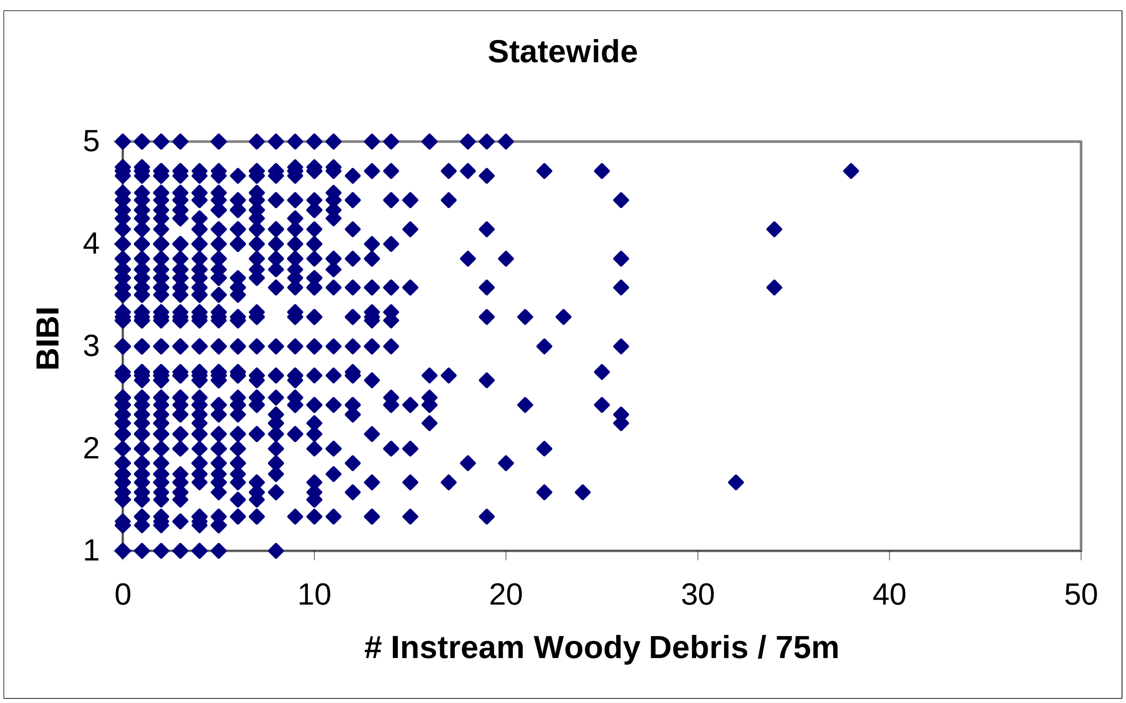

Figure 10-28. Relationship between BIBI scores and instream wood at 2000-2004 MBSS sample sites, statewide

The velocity/depth diversity metric recorded as part of MBSS data collection is intended to characterize the variety of velocity and depth regimes in the stream segment (slow-shallow, slow-deep, fast-shallow, and fast-deep) and reflects the heterogeneity of available riffle and pool habitats. Statewide, the total number of instream wood (woody debris and rootwads) was positively correlated with velocity/depth scores ($p < 0.0005$, $r^2 = 0.01$) indicating that streams with more instream wood have a variety of riffle and pool habitats available for aquatic organisms (Figure 10-29).

10.8 BEAVER ACTIVITY

Beaver are a natural part of Maryland landscapes and are considered by many to be a keystone species because of the effect they have on their environment and on other species. Beaver activity, especially tree cutting and dam building, fundamentally changes both instream and riparian habitat. Beaver dams can reduce channel scouring, store sediment, recharge groundwater, and mitigate flooding (Naiman et al. 1988). These changes can enhance natural stream functions and provide habitat for aquatic organisms, especially those adapted to slow and deeper water. Beaver alter the built environment as well, sometimes causing flooding and removing trees that shade trout streams.

Beaver activity was recorded as part of the 2000-2004 MBSS and was found to vary dramatically among counties (Figures 10-30 and 10-31). The statewide average was 6% of stream miles being affected by beaver activity. The greatest extent of beaver activity was observed in Charles (26%), Kent (25%), and Cecil (28%) counties. Beaver activity was not observed in eight Maryland counties during 2000-2004, but beaver populations likely exist in most of these counties.

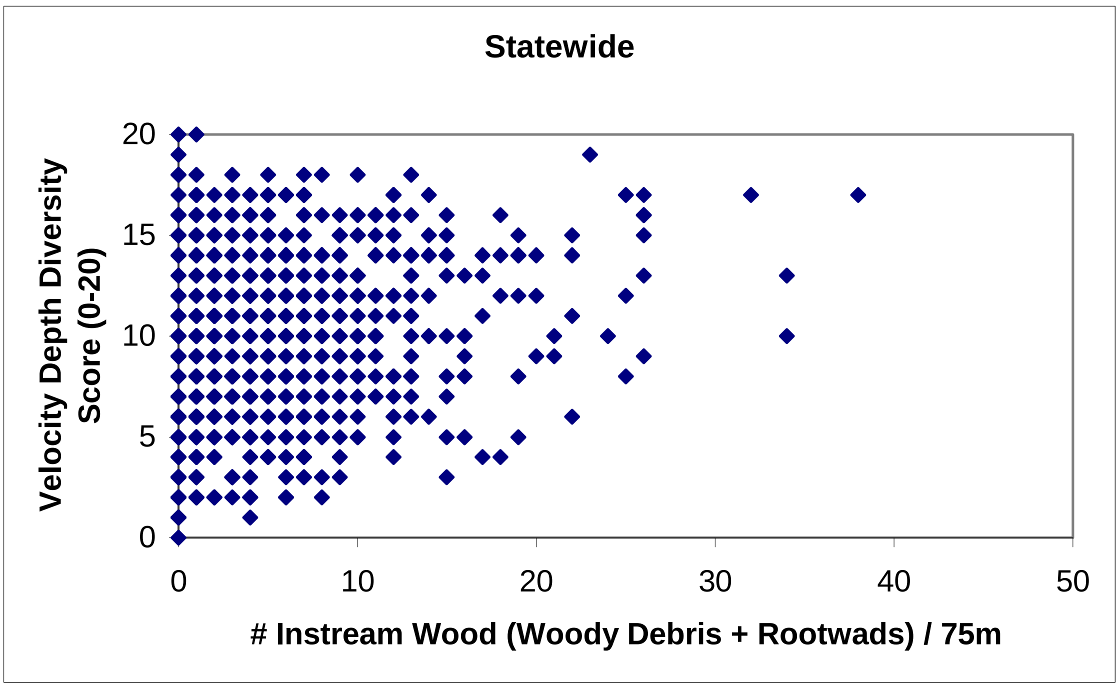

Figure 10-29. Relationship between velocity depth diversity metrics scores and total instream wood at 2000-2004 MBSS sample sites, statewide

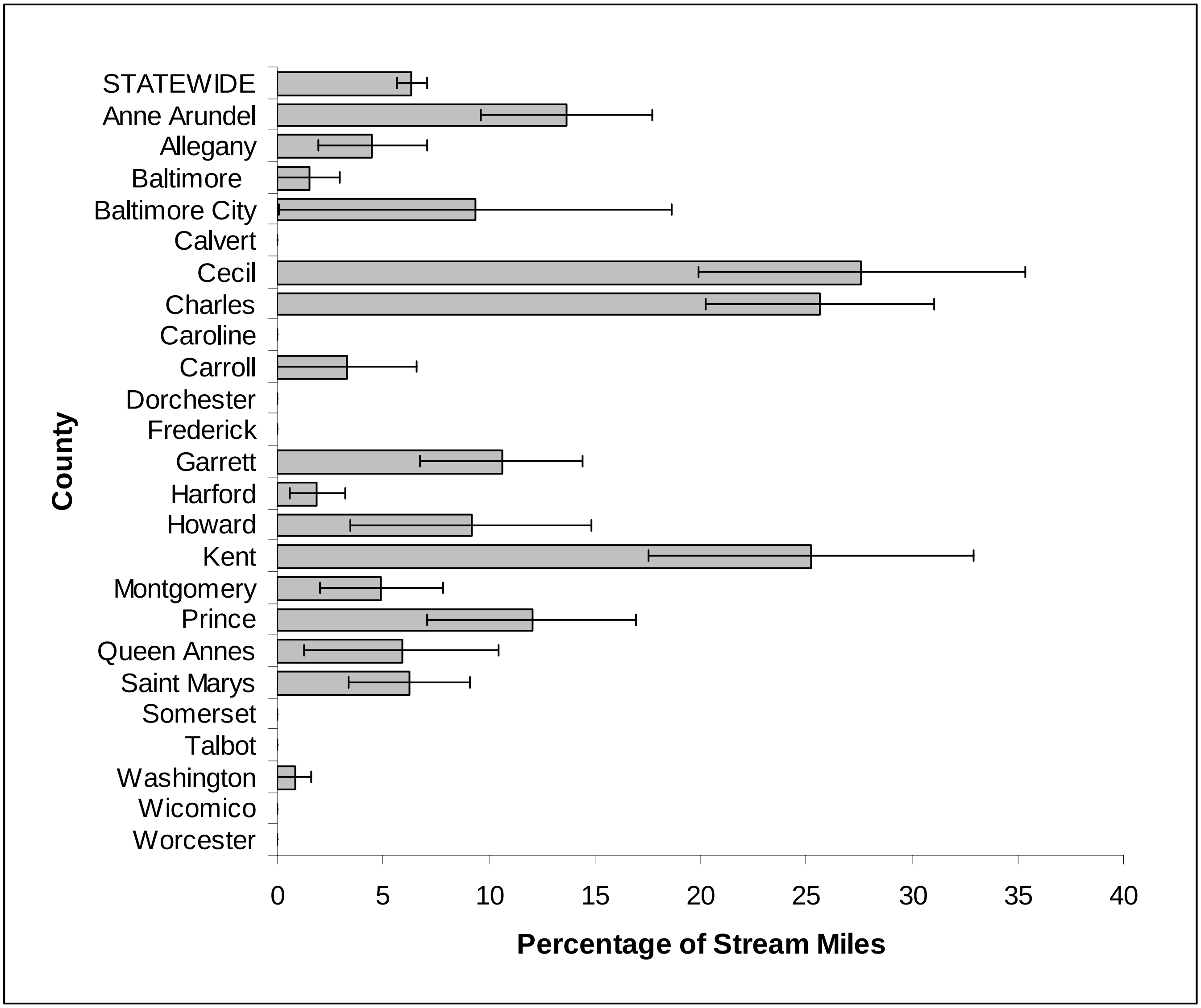

Figure 10-30. Percentage of stream miles with beaver activity, statewide and by county based on 2000-2004 MBSS data

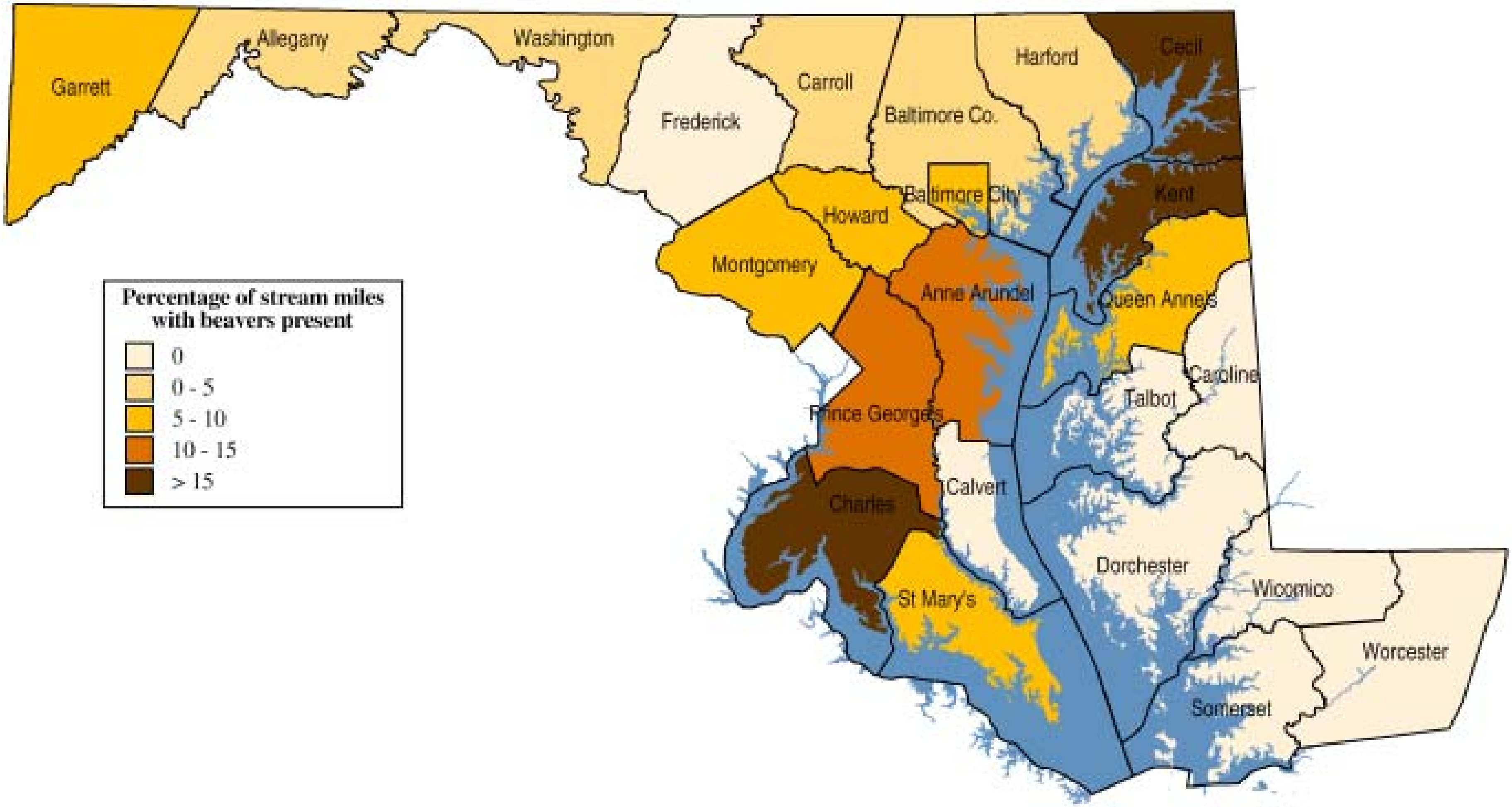

Figure 10-31. Percentage of stream miles affected by beaver activity based on 2000-2004 MBSS data, statewide by county

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